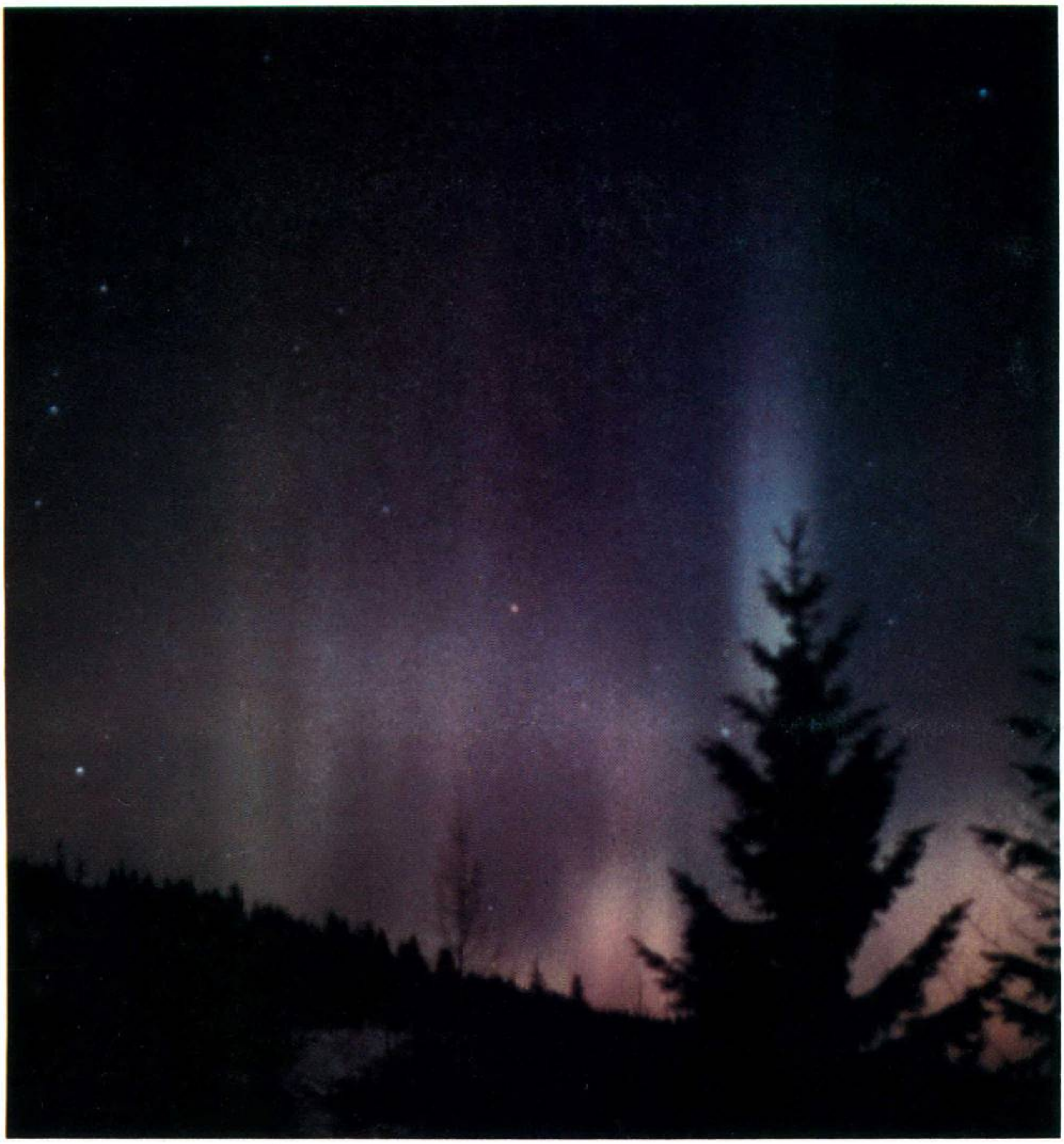
ASTRONOMY

JUNE 1978

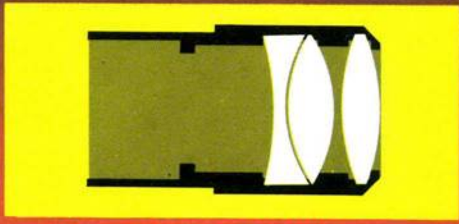
$1.50



Edmund Scientific has engineered a breakthrough in eyepiece design and pricing.

Innovation has rarely been so successfully applied as in the development of our new line of top-performance, moderately-priced RKE Eyepieces. Simply stated, we wanted to exceed the performances of widely-used American and foreign made eyepieces costing up to 60% more.

Our engineers used computer analysis to evaluate both the strengths and weaknesses of the best eyepieces available today. From these data, it was determined that with proper design and glass selection minimal aberrations could be achieved with only 3 optical elements, resulting in a substantial cost savings. Full ray-traces of all aberrations applied to glasses of high refractive index enabled Edmund to develop this unique 3-element system which equals or exceeds the performance of eyepiece designs using more optical elements.



The exclusive design of the RKE Eyepiece family coupled with the quality of its optics admits more light, is free from false colors and offers a sharply-focused, wide-field view of 60°.

The three RKE focal lengths were chosen to provide maximum versatility for your telescope. With par-focal design, these eyepieces are convenient to use and provide comfortable eye relief.

The RKE's are American made in our own optical facility using only the finest optical glasses with effective anti-reflection coatings. They are eyepieces we are proud to offer and that you'll be proud to own.

You can improve the performance of your telescope today at a remarkably affordable price with any or all of Edmund's new family of RKE's. Each is only $29.50 postpaid.

Order today with the coupon. Your complete satisfaction is guaranteed. (OEM and dealer inquiries are invited.)

The Edmund RKE Breakthrough:

A new standard in eyepiece performance at a price you can afford.

"The RKE Eyepiece yields incredibly good definition over the entire field of view. It outperforms eyepieces costing twice as much."

— Terry Dickinson

"Tremendous apparent field, combined with comfortable eye relief make the RKE 28mm the most spectacular deep-sky eyepiece I've ever used."

— Leo Henzl

28mm Eyepiece
No. 30,787

Effective F.L.	28.7mm
Eye Relief	24.5mm
Apparent Field	60°
Field Stop Dia.	23.3mm
Barrel O.D.	Std. 1¼" (31.8mm)

15mm Eyepiece
No. 30,819

Effective F.L.	15.0mm
Eye Relief	13.4mm
Apparent Field	60°
Field Stop Dia.	11.9mm
Barrel O.D.	Std. 1¼" (31.8mm)

8mm Eyepiece
No. 30,820

Effective F.L.	8.0mm
Eye Relief	8.2mm
Apparent Field	60°
Field Stop Dia.	6.6mm
Barrel O.D.	Std. 1¼" (31.8mm)

Each $29.50 postpaid

EDMUND
SCIENTIFIC COMPANY

EDMUND SCIENTIFIC CO. Dept K-11 Edscorp Building, Barrington, NJ 08007

☐ YES, please send me the following RKE Eyepieces at $29.50 each plus $1.00 service and handling charge. I realize that I must be completely satisfied or return the eyepiece(s) within 30 days for a full refund.

Qty. Eyepiece(s)

______ 28mm No. 30,787 ______ 15mm No. 30,819

______ 8mm No. 30,820 (available May/June)

☐ Please send me latest FREE Edmund Catalog (K-12)

☐ Enclosed find ☐ Check ☐ Money order for total of $______

☐ Please charge my ☐ Am Exp. ☐ BAC ☐ MasterCharge

Card # ______ Interbank # ______

Expir. Date ______ Signature ______

Name ______

Address ______

City ______ State ______ Zip ______

NJ residents please add 5% sales tax.

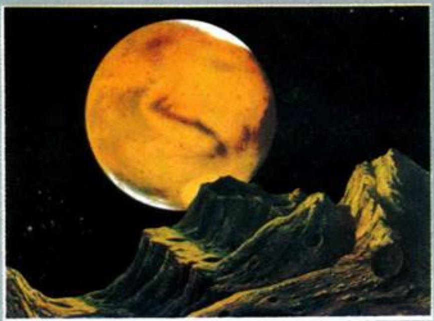
Inventory Clearance Sale!

Prices Reduced
on
Posters
Calendars
now ONLY $1.25 each

Milky Way in Sagittarius

Actual Poster Size: 17" x 22"

Better than a star atlas of this region, this breathtaking, colorful photograph by Orien A. Ernest shows clusters, nebulae and starclouds in their true relationship to each other and to the constellation Sagittarius' teapot asterism. In vivid reds, golds and blues, you'll see objects you can easily find with your naked eye or binoculars. Varnished; suitable for framing. $1.25 each.



Mars as Seen From Deimos

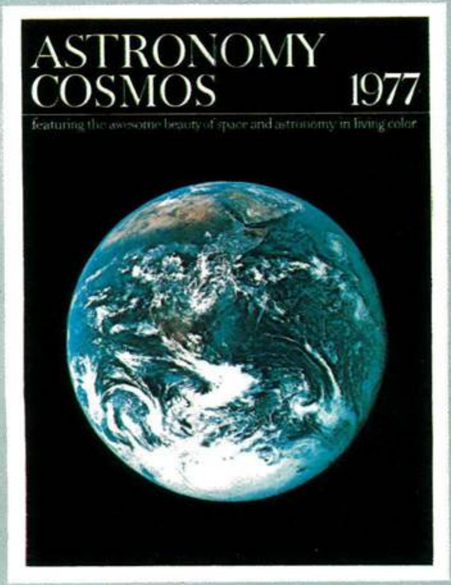
Actual Poster Size: 17" x 22"

Painted by Victor Costanzo, the red planet Mars and its outer satellite Deimos are set against a real stellar background. To the lower left of Mars is the Hyades, a star cluster in Taurus; at upper right is the constellation Aries. Varnished; suitable for framing. $1.25 each.

ASTRONOMY 1976 Sky Almanac

Opened Size: 11" x 17"

This full color calendar contains a series of 12 dynamic varnished reproductions of art and photographs from ASTRONOMY Magazine. As thrilling today as they were in 1976, you'll probably want to frame them! For an added bonus, ASTRONOMY 1976 Sky Almanac also contains maps of each month's sky — useful in any year — and introductory level observing projects. $1.25 each.


ASTRONOMY
COSMOS 1977
featuring the awesome beauty of space and astronomy in living color

ASTRONOMY Cosmos 1977

Actual Size: 8-3/4" x 11-3/4"

1977 may be "outdated", but astronomy . . . its drama and beauty . . . is timeless. ASTRONOMY's Cosmos 1977 calendar was designed to provide you with the most visually stunning view of the universe possible. Through 13 varnished, colorful reproductions of cosmic art and photos, you'll travel the universe from Mars to worlds beyond at the heart of a distant star cluster. Collect these illustrations . . . frame them (instructions are provided)! $1.25 each.

Start your own collection of cosmic art and photographs today! These impressive full color reproductions have been printed with the uncompromising care and quality found each month in ASTRONOMY, and will grace the walls of any room.

Quan.	Item	Price	Total
	Milky Way in Sagittarius	$1.25	
	Mars as Seen From Deimos	$1.25	
	ASTRONOMY 1976 Sky Almanac	$1.25	
	ASTRONOMY Cosmos 1977	$1.25	
	PLUS SHIPPING, HANDLING PER ORDER		$ .75
		TOTAL AMOUNT	

Payment must accompany your order.

Send check or money order to:
ASTRONOMY
411 E. Mason St. - 6th Floor
Milwaukee, WI 53202

Date:________________

Name____________________________
(please print)

Address____________________________

City __________ **State/Prov.** __________ **Zip** __________

Please allow 4 to 6 weeks for delivery.

Get "into" ASTRONOMY!

These colorful ASTRONOMY T-shirts are made of a blend of shrinkage controlled 50% cotton, 50% polyester. Prices include postage and handling.

ASTRONOMY
Magazine

Adult sizes: $4.75 each

Children's sizes: $4.50 each

Wear your ASTRONOMY T-shirt to your next club meeting or star party . . . and let your friends know you're really "into" ASTRONOMY!

ORDER TODAY!

QUAN	CHILDREN'S SIZES ($4.50)			ADULT SIZES ($4.75)				COLOR			PRICE
	M(10-12)	L(14-16)	XL(18-20)	S(34-36)	M(38-40)	L(42-44)	XL(46-48)	Lt. Blue	Red	Navy	
	TOTAL ORDERED							TOTAL PRICE			

Please charge to my: ☐ Master Charge
☐ BankAmericard/VISA

Expiration date: ____________

Date: ____________

Account Number ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Personal Signature ____________

Send check or money order to:
ASTRONOMY T-Shirts
411 E. Mason St. - 6th Floor
Milwaukee, WI 53202

VISA

master charge

Name ____________
(please print)

Address ____________

City ____________

State/Prov. ____________ Zip ____________

Please allow 4 to 6 weeks for delivery.

ASTRONOMY

The World's Most Beautiful Astronomy Magazine

June 1978 Vol. 6, No. 6

Established August 1973 by Stephen A. Walther

EDITORIAL
Managing Editor
Penny Oldenburger

Editor
Richard Berry

Staff Writer and
Astro-News Editor
Mary Jane Lamers

Contributing Editors
James Mullaney
James E. Oberg
Henry J. Phillips

Contributing Photographers
Bob Provin
Brad Wallis

GRAPHICS
Production Manager
David A. Schwartz

Staff Artist
Mark Paternostro

CIRCULATION
Subscriber Relations
Jodi Groth
Rosemary L. Pickart

COMMUNICATION
Information Officer
Penny Oldenburger

6 ASTRONOMICAL SPECTROSCOPY
by Robert Stencel, William Blair, Susan Conat-Stencel

20 MOON AND EARTH

22 ASTRONOMY REVIEWS

25 GUIDE TO BACK ISSUES

26 SKY ALMANAC
Asteroids at Opposition, Planets in Conjunction

28 PLANET FINDER — JUNE 1978

32 GAZER'S GAZETTE
Solar Eclipse 79
by Dan Koehler

34 Naked Eye Astronomy, Part 1
by Robert Burnham

42 PHOTOGRAPHY IN ASTRONOMY
Astrophotography - With Camera Only!
by Richard Berry

48 STELLAR FRONTIERS
Gravity, Dust and Solar Neutrinos
by John Gribbin

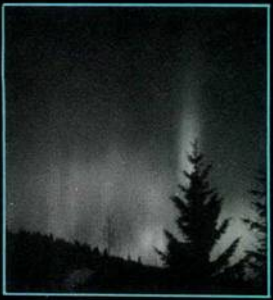
59 ASTRO-NEWS

65 ASTRO-MART

69 POSITIONS AVAILABLE

73 JUNE STAR DOME
by Henry J. Phillips and James Mullaney

75 Close-Up on the Libra/Lupus Region

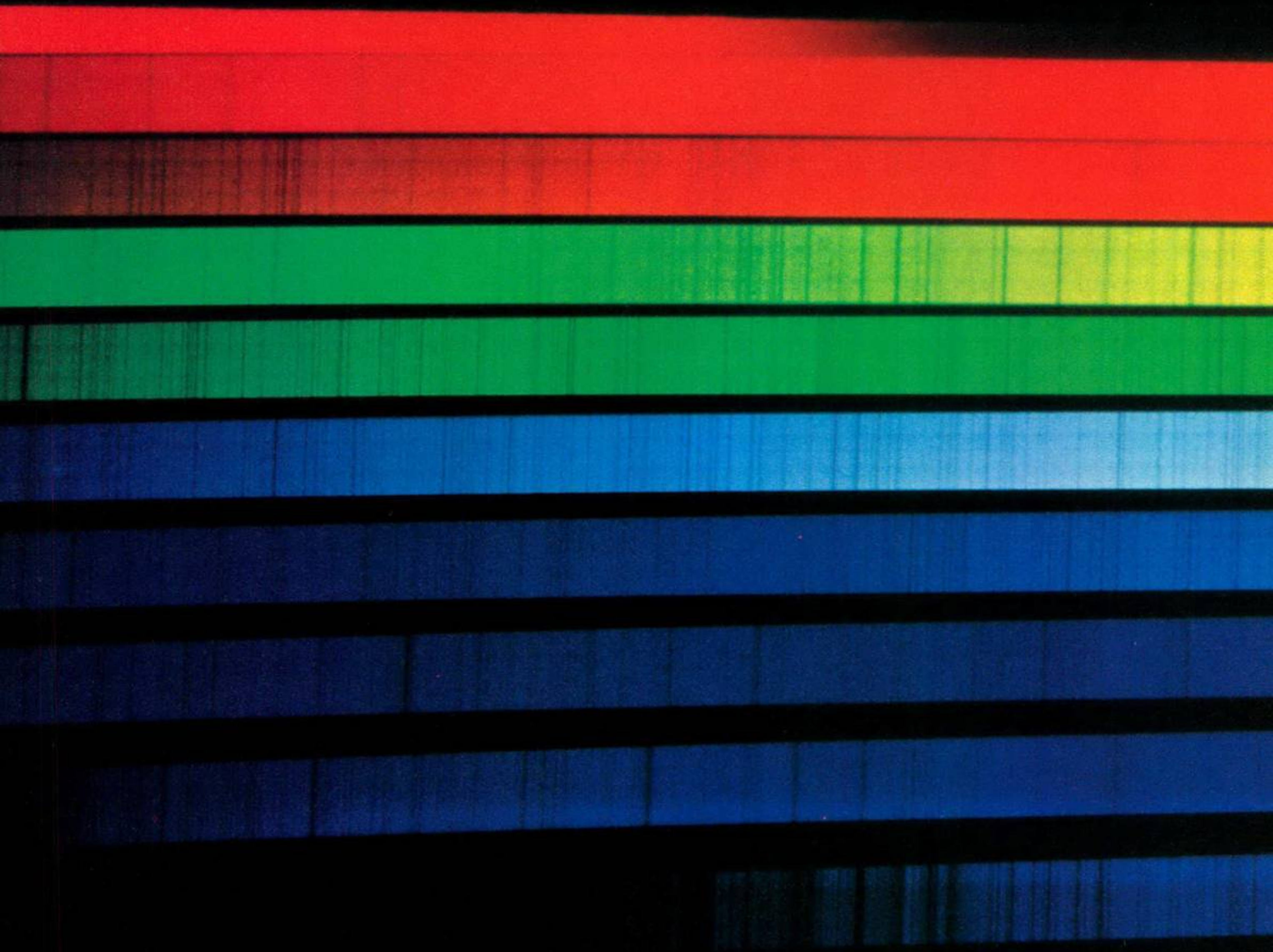


Cover

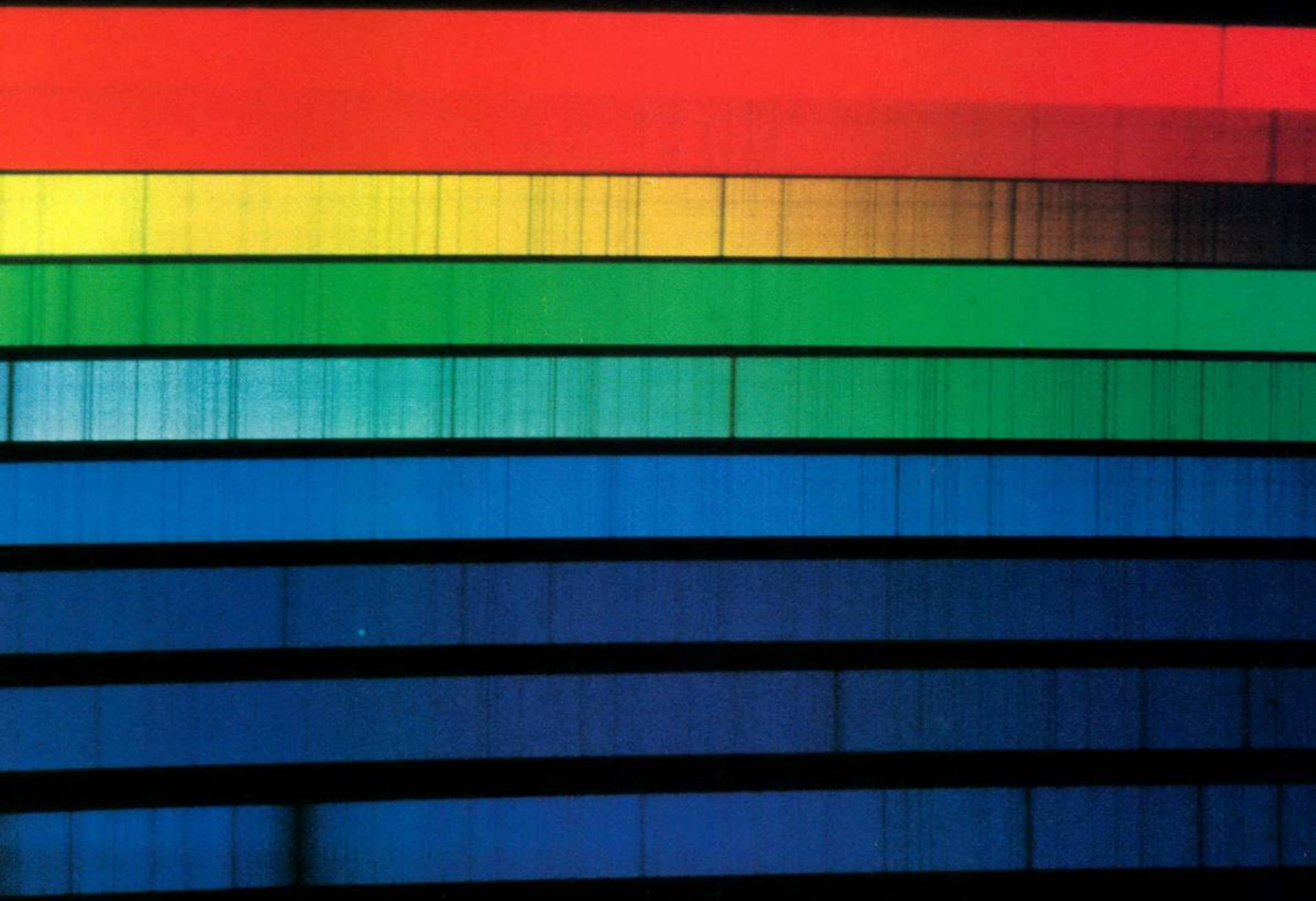
There's a wealth of enjoyment in astronomy that requires no telescope at all — only your eyes and your desire to get out and look! With summer weather as an encouragement, June is the month to learn the spring constellations in the early evening before they set — and then await the rise of the Milky Way to its full glory. This month ASTRONOMY explores a most productive branch of astronomy: spectroscopy, the study of spectra — rainbows of color that tell what stars are made from. We also look into the solar neutrino problem, and one scientist's speculations on what might be happening. And we're sure you'll want to see the February 1979 North American solar eclipse — so check Gazer's Gazette! Our cover shows a magnificent aurora seen from Colville National Forest (Wash.) on Jan. 30, 1978, recorded with a camera on a tripod and a 15 second exposure at f/1.8 on Ektachrome 200 film. Photograph by Don Carney.

Published monthly by AstroMedia Corp., 411 E. Mason St., 6th Floor, Milwaukee, WI 53202. Copyright © 1978 by AstroMedia Corp., all rights reserved. No part of this issue may be reproduced by any mechanical, photographic or electronic process, or otherwise copied for public or private use without written permission of the publisher. Second class postage paid at Milwaukee, WI. POSTMASTER: When undeliverable, send form 3579 to publisher. Direct all new subscriptions, changes of address, renewals and subscription bill payments only to ASTRONOMY, Circulation Services, 411 E. Mason St., 6th Floor, Milwaukee, WI 53202 and allow six to eight weeks for new subscriptions and changes of address to take effect. To speed service on subscription correspondence, complaints, photographs, slides, manuscripts and editorial correspondence write ASTRONOMY, 411 E. Mason St., 6th Floor, Milwaukee, WI 53202. Telephone (414) 276-2689. Due to the limited availability of back issues, new subscriptions must start with the most current month's issue. Cover price, $1.50. Subscription price: 1 year, $12.00. Canada & Mexico: add $3.00 per year. All other foreign: add $6.00 per year. ASTRONOMY is indexed in *The Readers' Guide to Periodical Literature*. Microfilms of all issues of ASTRONOMY are available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 44691. Additional office staff: William Stanfield, Production Assistant; Katherine King, Editorial Assistant; Judy O'Dair, Editorial Secretary; Stephanie Kiel, Administrative Assistant; Nancy Faustmann, Executive Secretary and Bulk Copy Sales; Bruce Precourt, Mail Room Supervisor. Accountant: Dennis K. Wilk. Consulting Editors: Thomas C. Bretl, John Harmon. Contributing Artists: John W. Clark, Adolf Schaller. AstroMedia Corp. officers: Robert Maas, President; Penny Oldenburger, Vice President. Typesetting by Grafilm, Inc., Milwaukee, WI 53210. Production photography by Communi-Graphics, Milwaukee, WI 53211. Separations prepared by Colorcraft, Inc., Milwaukee, WI 53216. Printed by E.F. Schmidt Co., Menomonee Falls, WI 53051.

AUDITED PAID CIRCULATION ABC



ASTRONOMICAL SPECTROSCOPY

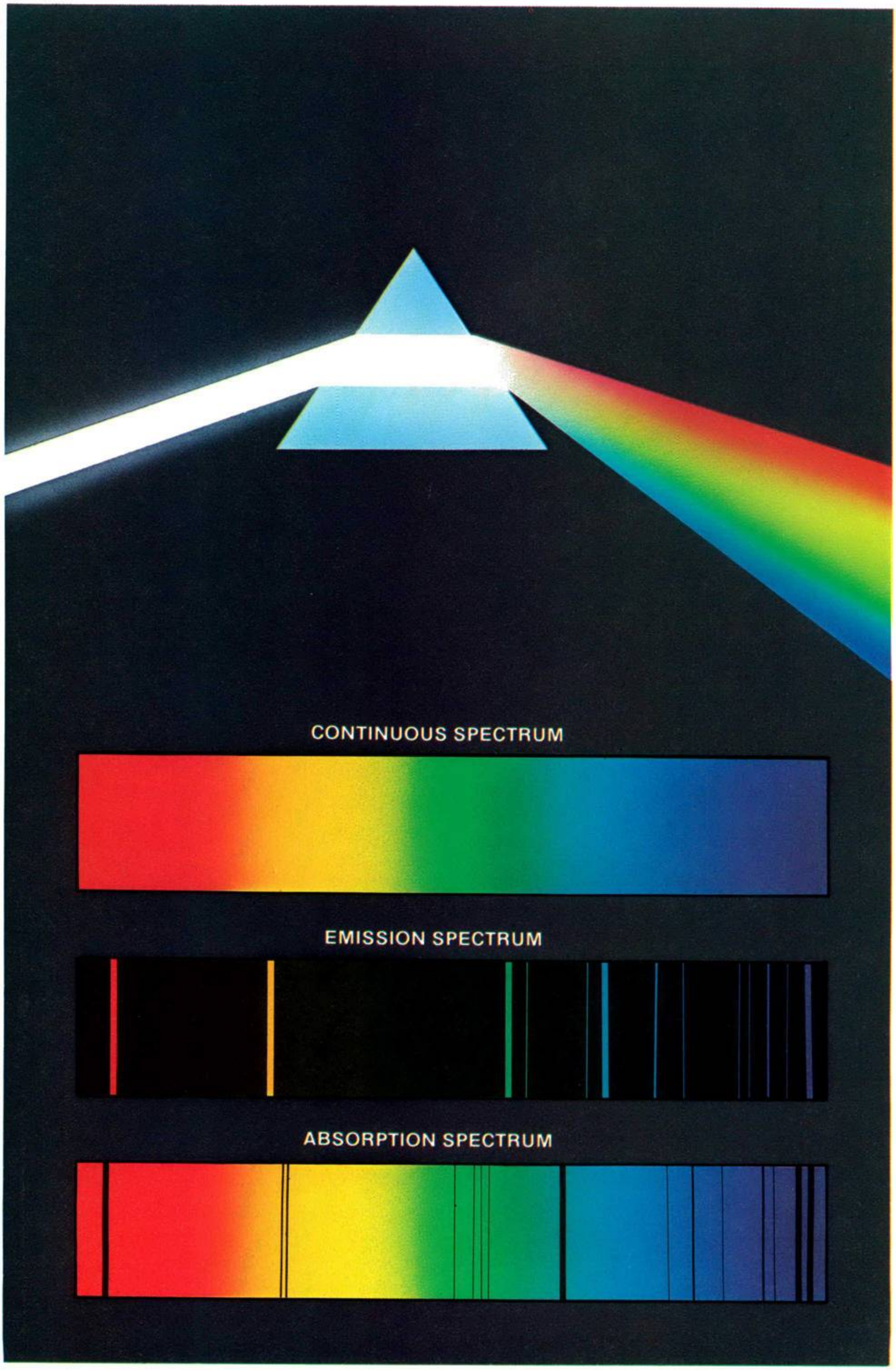


The spectrum of the sun is crossed by many thousands of absorption lines. The lines originate rather high in the sun's atmosphere, and represent energy removed from the spectrum by specific atoms and ions. Most of the chemical elements familiar to us on Earth have been detected and measured on the sun. One element — helium — was found on the sun, by spectroscopy, before it was known on Earth. Sacramento Peak Solar Observatory photograph, copyright © 1976 by the Association of Universities for Research in Astronomy.

by
Robert Stencel
William Blair
and
Susan Conat-Stencel

Our unaided eyes give us a panoramic — though superficial — view of the universe. As we survey the starry dome of the night sky, we see only patterns of relative brightness and flickering colors — mere specks of light scattered across the sky. How could we guess what stars are made from — or the possibilities of their planets? Who could have conceived of the stars streaming in a grand galactic ensemble?

The nearest star to our solar system is well over four light-years (100 trillion miles) away. Suppose we want some information about this star: Suppose we want to know how hot it is, what it's made of, or something about its motion in space. Perhaps we'd like to know about some of the billions of other stars in our galaxy. Or, venturing further, how might we find out what other "galaxies" are and how distant they are? Our only contact, and the only physical communication we receive from these remote objects, is the *light* that reaches us. But given only the feeble glimmer of light trickling through a telescope, how can we ever expect to learn anything about them? Astronomers have devised several ways of analyzing starlight for the information it contains; the most fruitful of them is called *spectroscopy*.


CONTINUOUS SPECTRUM
EMISSION SPECTRUM
ABSORPTION SPECTRUM

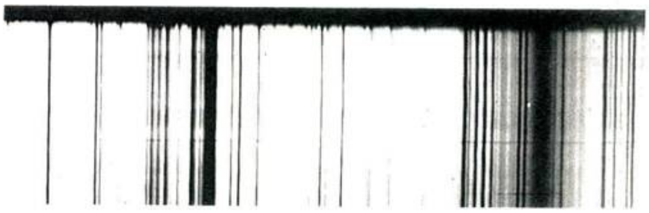
Light can be conceived as *electromagnetic radiation* — a disturbance of electric and magnetic fields that expands at high velocity. Most light we see is actually a mixture of many different colors rather than a pure entity having a single wavelength. As light passes through a transparent medium (such as water or glass), the different colors of light separate or *disperse* into a brightness pattern which is called a *spectrum*. A rainbow, for example, is created when sunlight passes through raindrops and is dispersed. You may have also seen spectra while toying with a prism in sunlight. Light enters one side of the prism and the spectrum of colors emerges from the other side of the prism. Dispersion occurs because the electromagnetic radiation interacts with electric fields between the atoms.

Sir Isaac Newton — the great English "natural philosopher" — was the first to experiment with prisms and light. In 1666, he passed a narrow beam of sunlight through a triangular prismatic chunk of glass. A continuous band of colors resulted. He also determined that the blue color always bent the most, while red bent the least. All other colors were bent to varying, intermediate degrees. Today we call the bright unbroken band of colors a *continuous spectrum*.

Prisms had been perfected by 1802, and William Wollaston reported he had found several dark lines crossing the continuous solar spectrum. He suggested these dark lines might be "natural boundaries" between the colors. Although he misinterpreted this, Wollaston may have been the first to see any hint of these features in the spectrum of the sun.

By 1814, a German physicist named Joseph Fraunhofer had made a breakthrough discovery: By placing an opaque object with a narrow slit in front of a prism, he found that a very narrow beam of sunlight would pass through it. Upon close examination of the resulting spectrum, he found some 600 dark lines crossing the spectrum. Some of the most prominent lines he designated with letters of the alphabet (several of these letter names are still used today). By 1826, Fraunhofer had measured wavelengths (the quantitative definition of color) of 324 lines in the solar spectrum. Because of his pioneering work, we still refer to the solar spectrum as the *Fraunhofer spectrum* (it is also called the *solar absorption line spectrum)*. Any spectrum crossed by such lines is an *absorption line spectrum*. Thousands of specific absorption lines have been measured in the solar spectrum.

The major advance in spectrum physics occurred in 1859 with the studies of Gustav Kirchhoff and Robert Bunsen. They developed the spectroscope, a device which allowed scientists to examine spectral features in great detail and permitted precision wavelength measurement of spectral lines. They found — through a lengthy series of experiments — that light from substances which were heated to a glowing gas displayed a series of bright lines when viewed with the spectroscope. A bright line spectrum is now referred to as an *emission line spectrum*. They found that *different substances* caused *distinctive patterns* of emission lines, whereas different samples of the *same substance* always produced the same, *unique pattern* of lines. They also noticed that if a bright source of a continuous spectrum was placed behind the source of an emission spectrum, the combination produced an *absorption spectrum with dark absorption lines exactly coincident with the emission line pattern!*



There are three basic types of spectra. Continuous spectra are emitted by hot solids, such as the filament in an electric light bulb. Emission spectra are emitted by excited or hot gases, such as the spectrum of helium shown here. Its spectrum permits helium to be identified whenever it becomes sufficiently hot to emit or absorb light. Absorption spectra occur when a cool gas lies in front of a hot solid. The solar spectrum here displays lines of hydrogen, sodium, calcium, iron and magneium. Diagram by Mark Paternostro.

The three different types of spectra (continuous, absorption and emission) aided the understanding of astronomy as astronomers rapidly grasped the importance of the discoveries — each element in nature has a characteristic spectral signature. Soon hydrogen, sodium, iron, calcium and nickel — common Earthly elements — had been found in the sun and stars! At last mankind had a vital tool for studying the composition of remote stars.

But the work was difficult, for human eyes are poorly adapted to the demands of exacting spectroscopic measurement. By the 1890's, photographic materials finally had the sensitivity required for astronomical purposes. The step from spectro*scope* to spectro*graph* was natural enough; furthermore, spectrograms (spectrum photographs) preserve the spectrum for future analysis and reference. This photographic record also helps in finding more accurate wavelengths, because a comparison spectrum can be placed beside the spectrum being studied. A comparison spectrum is simply a pattern of emission lines produced by a laboratory light source with well-documented wavelengths. Comparison lines act as a precise "measuring stick" in the determination of unknown astronomical line wavelengths. By using photography, astronomers gained another important advantage: the ability to record extremely faint spectra with long exposures at the telescope.

One final major development in spectroscopy was an improved alternative to the prism for dispersing light — devices called *diffraction gratings*. A diffraction grating is made by the precision etching of a huge number of closely spaced parallel grooves onto a glass or metal master. Some gratings used in astronomy have more than 15,000 tiny grooves per inch.

Astronomers prefer gratings since they disperse light into a wider and more uniform spectrum than prisms can. The higher dispersion — and higher efficiency too — allows more extensive analysis of selected portions of the spectrum at a high resolution.

The advent of computers and other electronic technology has caused a revolution in the methods of astronomers. Modern light detectors are rapidly replacing photography at the telescope. Using ultrasensitive television cameras, spectra are recorded on magnetic tape for direct playback into a computer. Even as you read this, astronomers are probing the radio, infrared, ultraviolet, x-ray and gamma ray wavelengths, utilizing new technologies both from ground level as well as Earth orbit (see "The Revolution in Astronomy", ASTRONOMY, November 1977).

Stellar Spectroscopy

The stars yielded their fundamental secrets to astronomers using early visual spectroscopes. William Huggins, an English amateur astronomer, was one of the first to show that stars are made of the same elements as the sun, Earth and human beings — hydrogen, sodium, calcium and so on. The spectroscope also proved that stars had to be giant balls of gas, and gave clues to how hot they had to be. Astrophysics — the study of the true nature of astronomical bodies — then began in earnest, supplanting the 19th century specialization in stellar positions.

As soon as sensitive photographic emulsions became available, observers began systematically collecting stellar spectra and attempting to put them into some order. Initially, stars were classified according to the strengths of the most prominent spectral feature of stellar spectra — hydrogen spectrum lines — in an A, B, C . . . scheme. However, after a few years, spectroscopists discovered that stars could be arranged into a sequence of stellar temperatures. They rearranged the previous classes into the famous "O-B-A-F-G-K-M" sequence of stellar spectral types (mnemonic: Oh Be A Fine Girl/Guy, Kiss Me!). The O and B stars are the hottest, while M stars are the coolest — about as hot as a light bulb's filament, which is cool enough to allow solids to exist in their atmospheres.

At the beginning of the 20th century, Harvard astronomers Annie Jump Cannon and E.C. Pickering produced the **Henry Draper Catalog** which contained the position, magnitude and spectral type of nearly 250,000 stars — a monumental work taking many years. Within the framework of the stellar temperature sequence, it quickly became clear that some stars having about the same temperature showed noticeable differences in the *sharpness* of their lines. Both Enjar Hertzsprung and Henry Norris Russell, independently studying this problem, discovered that most stars can be plotted onto a narrow region of a diagram comparing absolute magnitude and spectral type. This strip is known as the *main sequence* and contains highly luminous, blue-hot O and B stars, as well as yellow stars like our sun, and faint, cool, red M stars. All these stars share a common property: They all shine due to thermonuclear fusion of hydrogen into helium within their interiors. However, other regions of the Hertzsprung-Russell (HR) diagram are also sparsely occupied by stars.

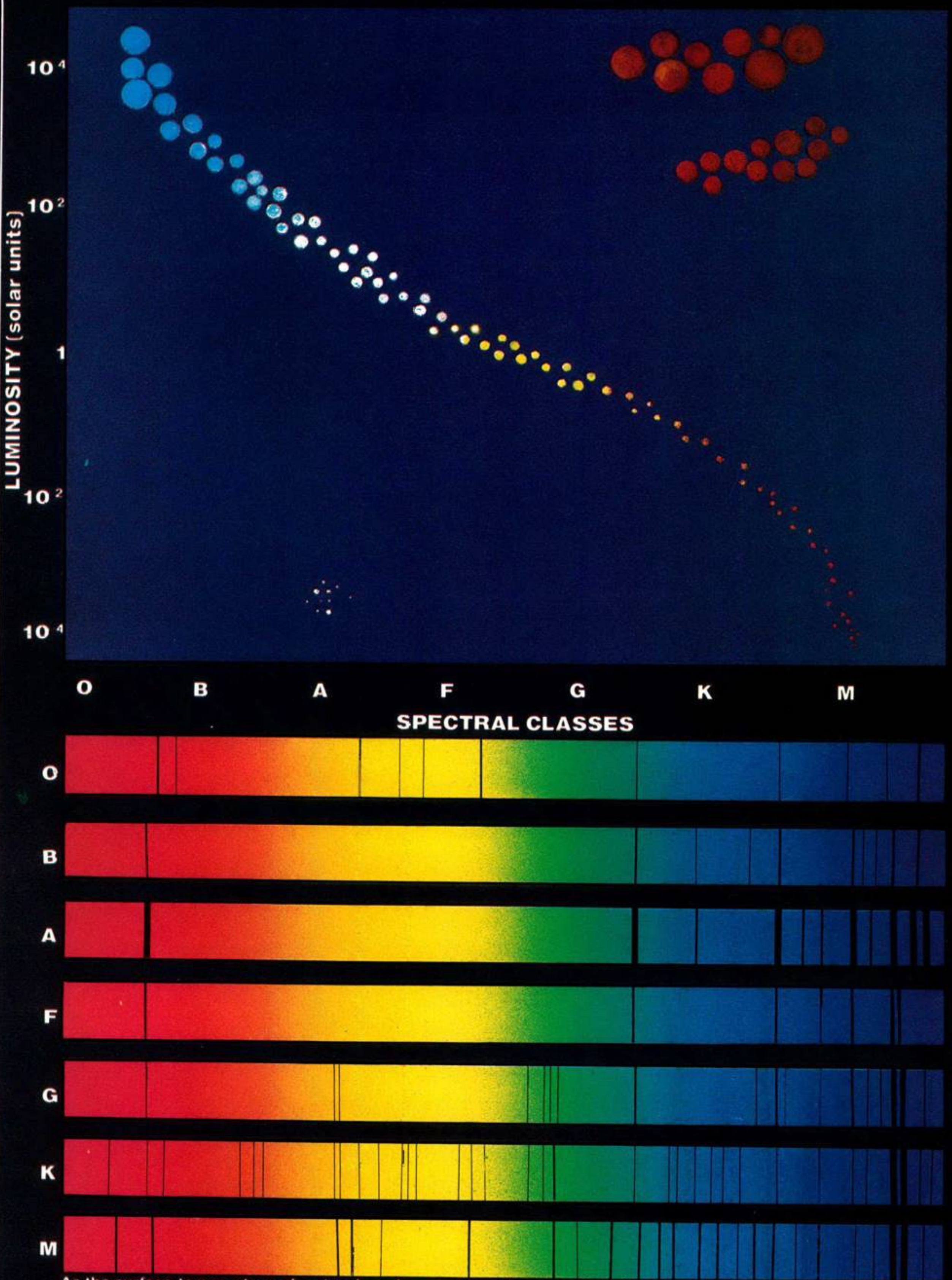
The stars with sharper lines formed a group above (brighter than) the main sequence. They turned out to be extremely large stars — 10 to 1,000 times the size of our sun — and so are named *giants*. Although most giants are cool and red, they are so large that their total light output greatly exceeds the sun's light output. Giants are in the throes of an energy crisis; their hydrogen is spent and the energy to be derived from fusion of heavier and heavier nuclei is short-lived and futile. Try as they may through violent contractions, their fuel is exhausted!

By comparison with the giants, stars of the main sequence came to be known as *dwarfs*. Fainter than dwarfs is another class of stars located on the HR diagram: hot, but very small, low luminosity *white dwarf* stars. These are thought to be the end products of a star's life — dense cinders left after all thermonuclear fusion processes have been exhausted. Because of the high pressure at their surfaces, their spectral lines are broad.

Although there are stellar mavericks (pathological stars, variables, binaries and novae) which are difficult to place in the HR diagram,the vast majority of stars can be plotted on an HR diagram and thus interpreted. Ever since its discovery, this has had a profound influence on the scope and direction of astrophysics.

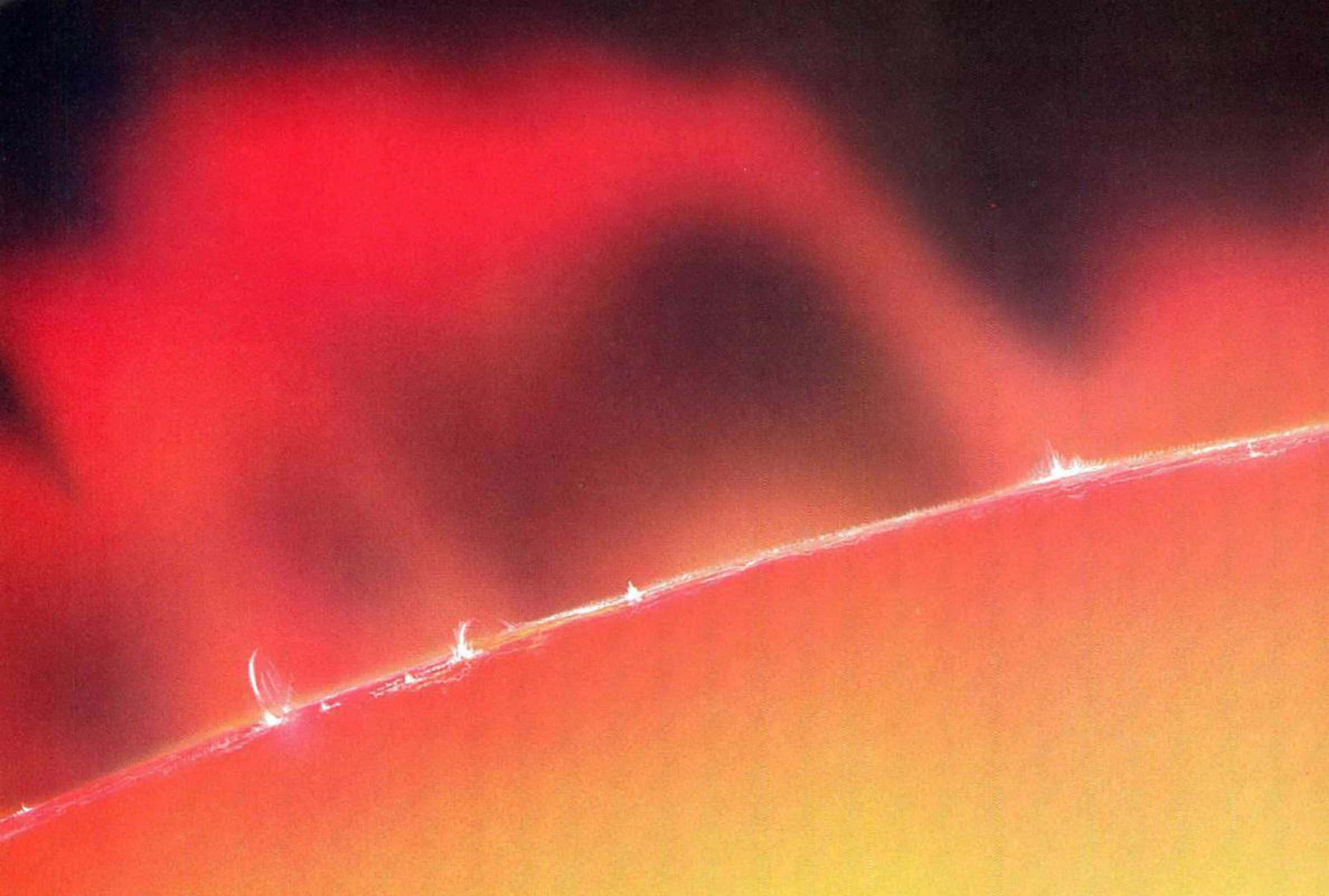
The HR diagram provides a means of finding distances in the universe, and also yields observational evidence for stellar evolution. In both, astronomical spectroscopy has been crucial. Spectroscopy provides a way of saying, "These stars ought to be identical because they have the same spectrum." If astronomers can directly measure — via the parallax effect — how distant a certain star is, they can establish its intrinsic brightness. Then, observing another fainter star with an identical spectrum gives *its* intrinsic brightness too. Using the inverse-square law for the dimunition of light intensity, astronomers obtain stellar distance by observing brightness! Thus, stars too distant for trigonometric parallax can be located with the technique of spectral parallax. Of course, for distant stars, interstellar matter can cause the light to dim even faster than the inverse-square law would predict. Indeed, discrepancies of this type were important in the discovery and exploration of

CLASSES OF STARS



As the surface temperature of a star rises, its spectrum changes. Even though the same basic elements are present, those which appear strongly in a spectrum serve as an accurate astrophysical thermometer. In the hot O and B stars, helium and ionized helium lines are present, but in the A stars helium is not excited enough to absorb. Instead, lines of hydrogen dominate the spectrum. F and G stars show weakening hydrogen lines and increasingly strong lines of metals; the spectra of K stars are totally dominated by metals. The still cooler M star spectra are dominated by absorption bands due to molecules of titanium oxide in the stellar atmosphere.

Artwork by Mark Paternostro

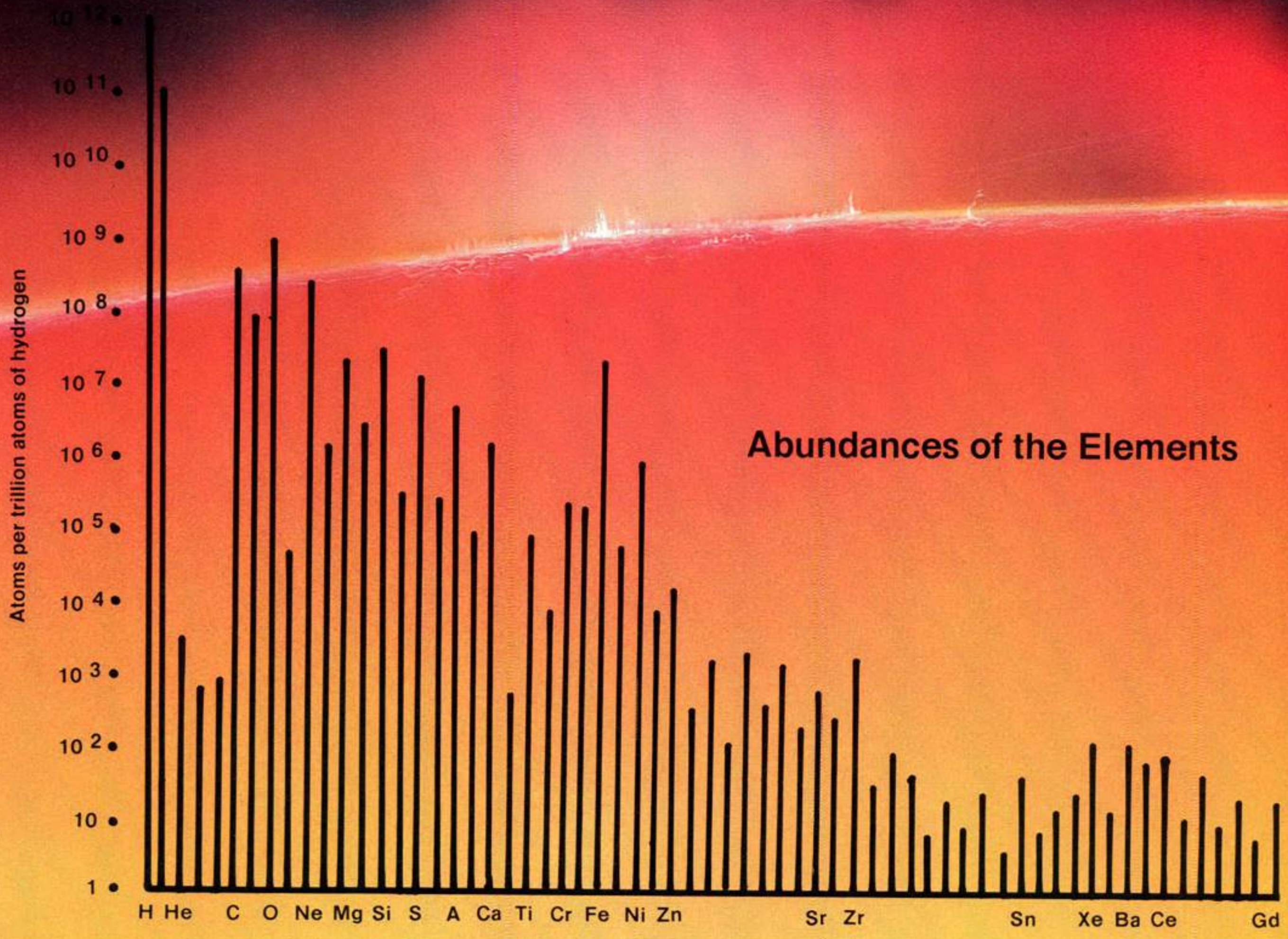


interstellar matter. Today interstellar absorption is understood well enough that astronomers can roughly compensate for interstellar matter to find a reliable distance of a star — despite such obstacles.

There is another situation in which spectral parallax works very well. Star clusters are composed of hundreds — up to millions — of stars, which are all at comparable distances from the sun. Spectra of each member can be combined into an apparent brightness-spectral type diagram to create an HR diagram for the cluster. By comparing the apparent brightness of main sequence cluster stars with the intrinsic brightness known for nearby main sequence stars, the distance for the entire cluster can be determined. By plotting the distribution of clusters in space — especially young ones — astronomers can explore the spiral structure of our galaxy (see "Swarms of Stars Cosmic Calibrators", ASTRONOMY, March 1978).

Besides being full of stars at the same distance, star clusters are invaluable for another reason: All stars in a cluster are approximately the *same age!* Allan Sandage of the Hale Observatories published HR diagrams for a variety of star clusters of different ages. It was clear by the late 1950s that as a cluster becomes older (as determined by its compactness and dust content), the hot upper left end of the main sequence "peels" away and moves to the right, or cooler portion, of the HR diagram, increasing the population of red giants and supergiants. In other words, the star changes from a main sequence type O star, for example, to a type M supergiant. In older clusters, the turnoff is well-defined, and a "beaten track" from the main sequence to the red giants is clear. From other studies, primarily of binary star orbits, we know the hot main sequence stars (upper main sequence stars) are far more massive than the cool, solarlike stars of the lower main sequence. The more massive the star is, the faster the thermonuclear fusion reactions at its center consume its available supply of hydrogen. Thus the hot, massive stars of the upper main sequence evolve toward the red giant region (where fusion of helium into carbon, etc. is possible) far more quickly than the cooler, less massive stars of the lower main sequence. Although stellar evolution has become a mature branch of astrophysical theory in the past two decades, astronomical spectroscopy sparked the contemplation of observational evidence for stellar evolution.

Consider what can be learned from analysis of individual stellar spectra: temperature, composition, surface pressure, strength of its magnetic field, rotation speed, size, probable age and place of origin. Of course, the limits of what can be inferred depend largely on the degree of *spectral resolution* possible,

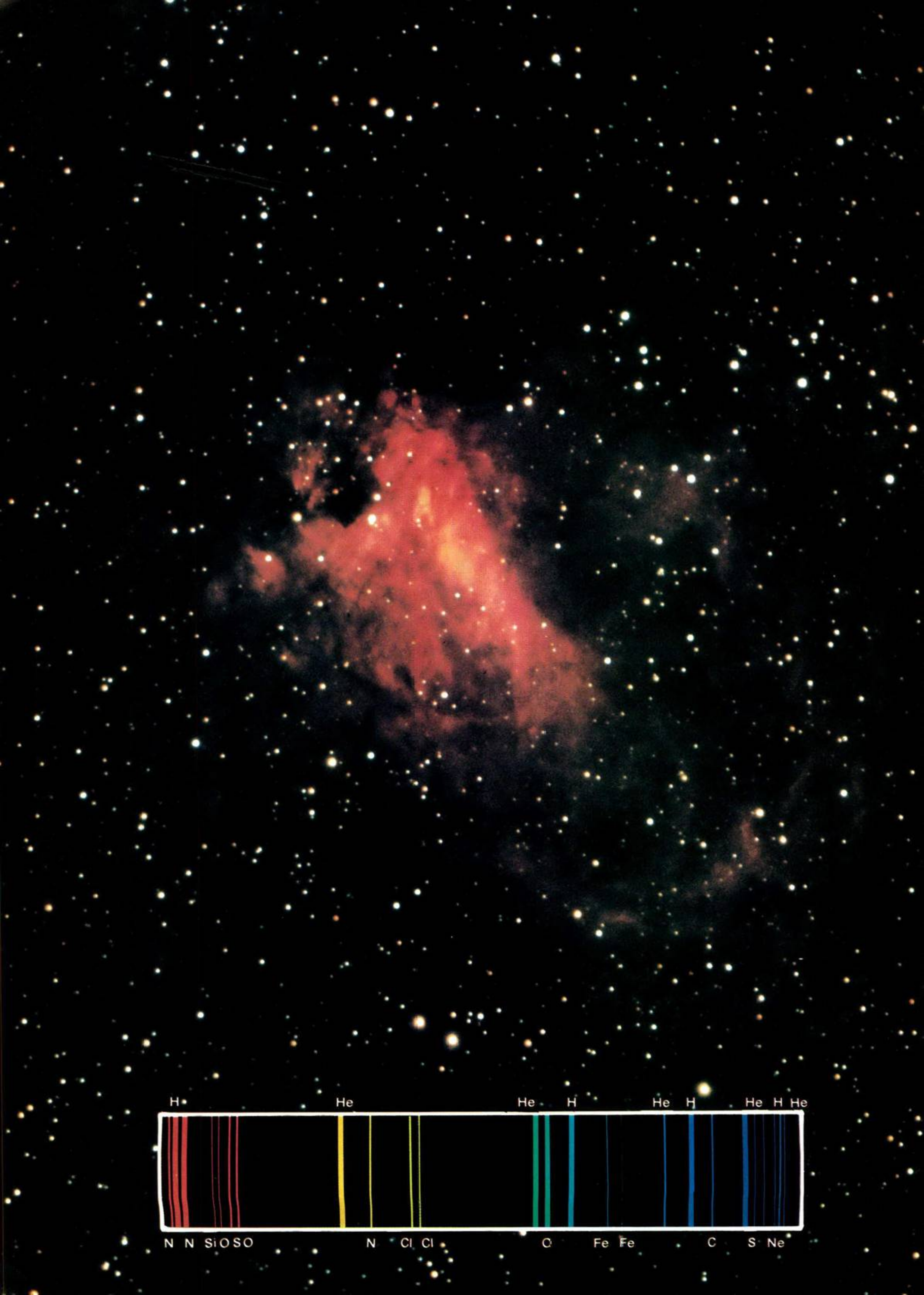


The bar graph shows the abundance of elements in the universe, as derived from spectroscopic studies of stellar atmospheres. The abundance is expressed relative to hydrogen: For each trillion hydrogen atoms, the graph shows how many atoms of that particular element are thought to exist, on the average. On Earth, the abundance of hydrogen and helium are markedly lower because Earth lost these elements at the time of its formation.

which is generally set by the faintness of the star. With the sun, the light's intensity permits detailed study of the spectrum: It can be spread up to 0.001 Ångstrom per millimeter (the visible part of the spectrum would be several *miles* long at this high resolution). With stellar photographic spectra, light is a limiting factor; diligent multihour exposures on a large telescope are needed to photographically record a fifth magnitude star at 10 Ångstroms per millimeter, and the complete spectrum would extend only the width of the page!

High dispersions permit more detailed examination of the star. More than classification, using the few darkest lines, becomes possible — hundreds, even thousands, of lines open new possibilities. The greatest recent advances in astronomical spectroscopy have been in the observational and theoretical analysis of individual lines in stellar spectra. Each atomic element has a unique pattern of spectral lines which signals its existence. In fact, each ionization stage and every isotope of each element has a unique spectrum — the details of which tell us of the thermal environment and even the thermonuclear history of the nuclei! The fundamental physical description of a stellar atmosphere — what astronomers really learn about — amounts to the height distribution of a few parameters: temperature, pressure, turbulence velocity and chemical composition. The profile of spectral lines, their pattern of intensity with wavelength, can be used in combination with our understanding of atomic physics to deduce these atmospheric parameters. Roughly speaking, the total strength of a spectral line relates to the chemical abundance and temperature, while the width infers pressure and turbulence velocity. Sophisticated computer programs which calculate the passage of light through a stellar atmosphere (radiative transfer) are being applied for the precise interpretation of astrophysical spectra. One of the principal labs doing this type of study is the High Altitude Observatory Division of the National Center for Atmospheric Research in Boulder, Colo.

The most outstanding results stemming from analysis of large numbers of stellar spectra are the description of cosmic abundances of the elements, and evidence for mass loss from stars. Both results have


H
He
He
H
He
H
He
H
He
N
N
Si
O
S
O
N
Cl
Cl
O
Fe
Fe
C
S
Ne

Left: While there is much to be learned from looking at pictures of stars and nebulae, spectroscopy zeros in on the most basic question: "What is it made of?" The spectra of nebulae usually show the presence of hydrogen, helium, carbon, oxygen, nitrogen, neon, chlorine, sulfur, silicon and iron. Photograph by Leo C. Henzl Jr. Above: The Crab nebula is the remnant of a supernova that exploded some 900 years ago. The remnant is still expanding, at speeds which can be measured by means of the Doppler shift. Lick Observatory photograph.

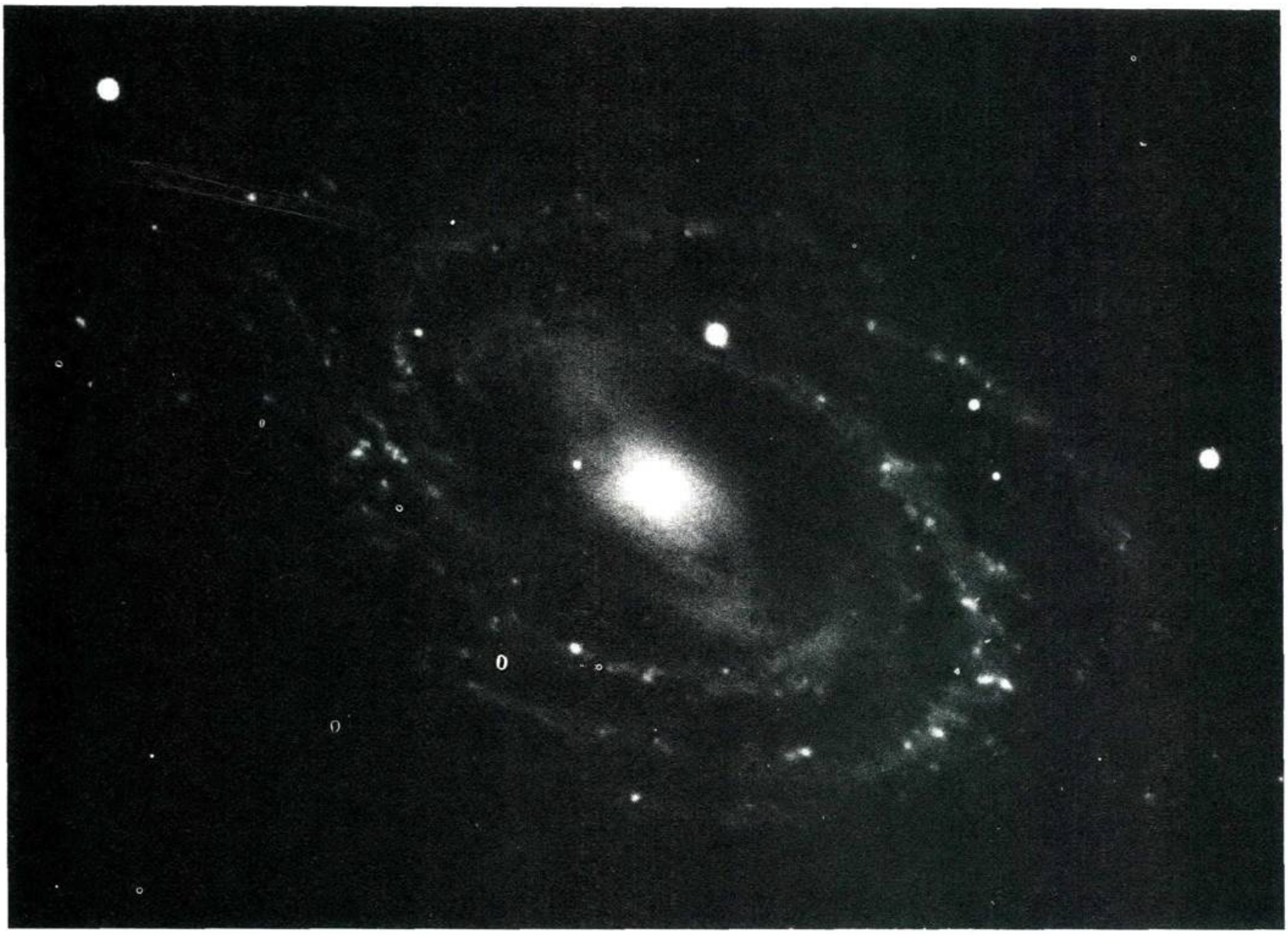
fundamental bearing on the ancient question of stellar evolution as it relates to the origin and fate of life in the universe. Stellar and nebular spectroscopy have so far demonstrated that the elements we know on Earth are the same as found throughout the visible universe, and that in the observable universe, hydrogen is far and away the predominant element — as though it were *ab initio.* In the interiors of stars and in the hypothetical big bang, all the heavier elements were created through thermonuclear fusion. Although the percentage of heavy elements produced in the big bang is debated, stars continue to produce helium and heavier elements in their interiors. Carbon, nitrogen and oxygen are thus astrophysical consequences of the nature of our universe. The range of atomic abundances and the subtleties of isotopic distribution are the clues that allow astrophysicists to trace the nuclear history of our own physical constituents.

But thermonuclear processes are hardly quiescent! The slow conversion of hydrogen into helium in our sun's interior must eventually lead to an energy crisis when all the hydrogen is consumed. The inevitable result, gleaned from stellar evolution studies, is the mutation of "our friendly Mr. Sun" into a "man-eating" red giant star which will expand and engulf our planet. In this expansion and during the subsequent thermonuclear processes (helium into carbon, carbon into still heavier nuclei) occurring in fits and starts, extensive mass loss from the solar atmosphere will mean thousands of tons of stellar debris will be blasted out into space — into the interstellar medium — enriching it with the heavy element products of thermonuclear fusion. From this enriched material, the next generation of stars will eventually begin forming as gravitational perturbations condense clouds of matter into protostars. Stars more massive than the sun undergo far less passive changes; frequently they explode, in what we call supernovae (see "Supernovae", ASTRONOMY, March 1977).

Distribution of the elements throughout the cosmos — elements which eventually condense into small pearly-white, blue and green-brown planets near average stars — is one of the many exciting discoveries that arises from stellar spectroscopy.

Exploring Space Through Spectra

Astronomers also employ spectroscopic methods to persue aspects of the glowing, nebulous objects which are seen in our galaxy. H-II regions (like the Orion nebula), planetary nebulae (of which the Ring is

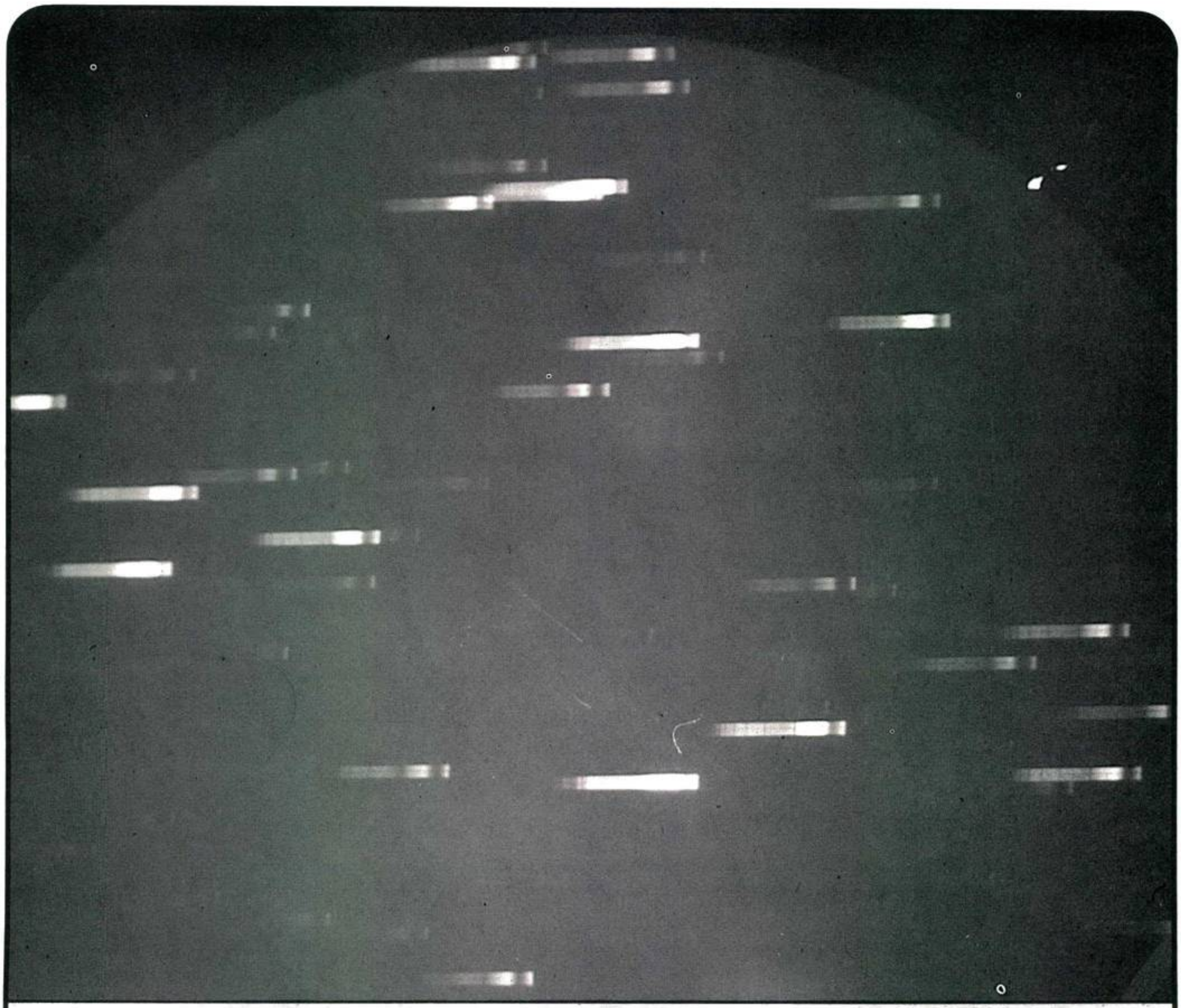


Distant galaxies are made of the same familiar stuff that our own galaxy, our sun, Earth and human bodies are. How do we know? The distant galaxies have the same spectra as aggregates of stars in our galaxy, and display spectral lines of the familiar terrestrial elements. Spectra also show that the galaxies are receding from us at speeds proportional to their distances. NGC-3992 photograph courtesy of Lick Observatory.

probably the best known), and supernovae remnants (like the Crab) usually exhibit *emission line spectra.* The lines come from elements such as hydrogen, helium, oxygen, nitrogen, neon, sulfur and some other less abundant elements. Thus, as with stars, spectra from these objects tell about their chemical compositions. More importantly, we can apply the findings of laboratory astrophysics to obtain information about the physical nature of the object — what's really going on out there in those clouds of gas! Through laboratory and theoretical investigations, we know the relative strengths of some emission lines vary with temperature, while the relative strengths of others vary with the density of material in the nebula. If an astronomer can observe those lines in the spectrum of the nebula, he can compare their relative brightnesses and thus determine the density and temperature of the object! From those data, plus size and distance, astronomers can derive the total mass; then, by applying physics of gravitation and radiation, they can determine whether such a cloud of gas might collapse to form stars, expand into space, or remain undisturbed, in equilibrium.

Even more directly, we know that because some parts of the planetary nebulae and supernovae remnants are coming toward us, while some parts are receding, they must be expanding. Relative motions alter the spectrum, so that part of the line is shifted toward the shorter blue wavelengths, while part of the line shifts to the red end. This effect is seen as a broadening of the line in the spectrum (that is, instead of a sharp, distinct emission line, it will appear blurred or ill-defined). The amount of broadening, therefore, can be interpreted as the *expansion velocity* of the object. If the distance to the object is known, we can then determine the size of the object and trace the expansion backward to see when it began. When this analysis was carried out for the Crab nebula, astronomers found that it should have begun its expansion around 1054 A.D., in agreement with the records of Chinese astronomers who recorded a supernova in the present position of the Crab in that year — powerful confirmation that the Crab is indeed a supernova remnant. Photographs taken many years apart also show this expansion.

The usefulness of spectroscopy does not end at the edge of our Milky Way galaxy. Indeed, we can actually record spectra for whole galaxies! The spectra obtained are similar to those of stars, but are much less detailed. Since light coming from a galaxy is simply the sum of the light from all the individual



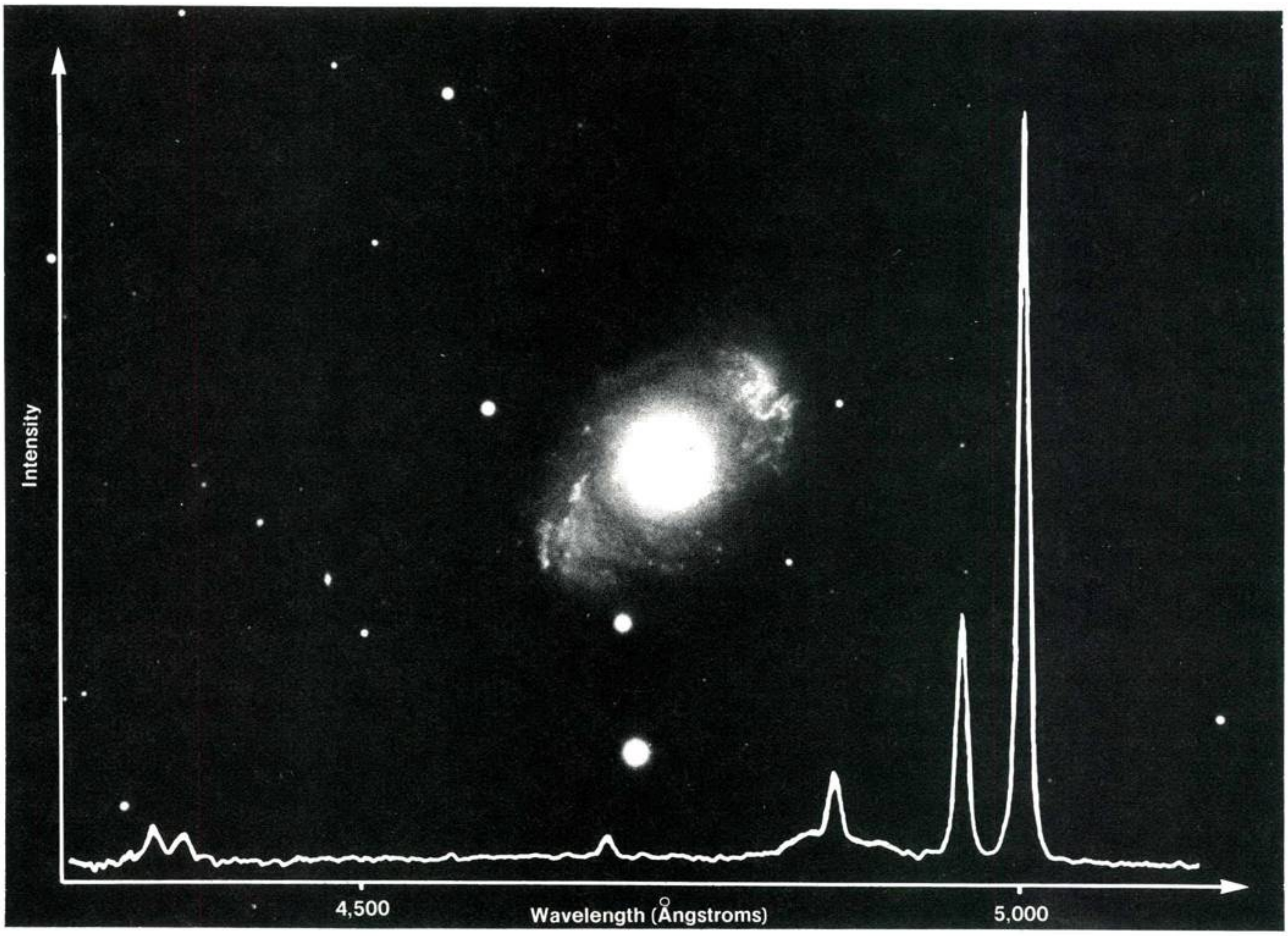
Surveying Stellar Temperatures

To obtain spectra of many stars at once, astronomers frequently use a large thin prism placed over the front opening of a telescope. "Objective prism" methods allow survey work at low dispersions (100 to 1,000 Ångstroms per millimeter) to search out and quickly detect unusual stars and galaxies whose unique spectral signatures will stand out even in a crowded star field.

At low dispersions, a large portion of the star's visible spectrum will be recorded. The distribution of the brightness of colors in a stellar spectrum indicates the average temperature of the star. A cool star (Betelgeuse or Antares, for example) will have red predominating, while a hot star (Rigel or Vega) will show strong bluish spectral intensity. Our sun, an intermediate in the stellar temperature range, has its strongest spectral intensity in the yellow-green.

The reason we can use a star's overall spectral intensity distribution to estimate its average temperature involves a law of physics of radiating objects empirically deduced by physicist Max Planck at the turn of this century. For a given temperature, Planck's law predicts the intensity of each spectral color. Upon matching the star's spectral intensity distribution, astronomers deduce an *effective temperature* to describe the star's radiating atmosphere.

Stellar absorption line strengths can also be used to determine stellar temperatures, and were instrumental in setting up the spectral type sequence on a temperature basis. From laboratory experiments augmented by quantum physics, the variation with temperature in the strengths of the hydrogen lines is known. Therefore the relative strengths of these lines in stellar spectra indicate temperature as well.



NGC-4151 is a Seyfert galaxy. It is distinguished from normal galaxies by having a small, bright nucleus and an abnormal spectrum. The spectrum shown here (as a graph of intensity versus wavelength) displays intense, broad emission lines. Hot clouds of gas are moving rapidly away from the core of this galaxy. Seyfert galaxies may be the link between normal galaxies and quasars. Spectral scan courtesy of the McGraw-Hill Observatory of the University of Michigan, used with permission of the Astrophysical Journal. Galaxy photograph courtesy of Hale Observatories.

stars, the lines we see in the galaxy spectrum give us a clue to the dominant star population of that galaxy. For instance, if a galaxy spectrum contains the H and K lines of singly ionized calcium, we know the galaxy contains a large number of cooler stars (spectral types G through M), as singly ionized calcium lines are prominent in the spectra of these stars. Lines of hydrogen and helium are prominent in hotter stars, and if these lines appear in the spectrum of the galaxy, we can infer that it contains younger, hot, O through F type stars. Thus, the spectra of galaxies reveals their relative ages and states in evolution. The spiral galaxies, with their thick dustclouds, have many blue-hot young stars. Elliptical galaxies are generally dust-poor and lack young stars, and so are mostly populated by older cool red giants.

Galaxy spectra have another similarity to stellar spectra: We can determine the shift of their spectral lines, and thus calculate their velocity with respect to our own galaxy. When this is done for a large number of galaxies whose distances are known, we discover an amazing fact: The more distant the galaxy is, the faster it is moving away from us!

This is usually attributed to the fact that the universe is expanding (see "Rival Cosmologies", ASTRONOMY, March 1978). If you liken the universe to a loaf of raisin bread, and think of the galaxies as raisins, you can visualize what is happening. As the bread is baked, the dough expands, and the separation between each raisin increases. If we "lived" on one of the raisins, we would observe the other raisins moving away from us at velocities directly proportional to their distances. Hence, the farther the raisin (galaxy) is from us, the faster it recedes. The raisin observers would conclude that the whole loaf was expanding.

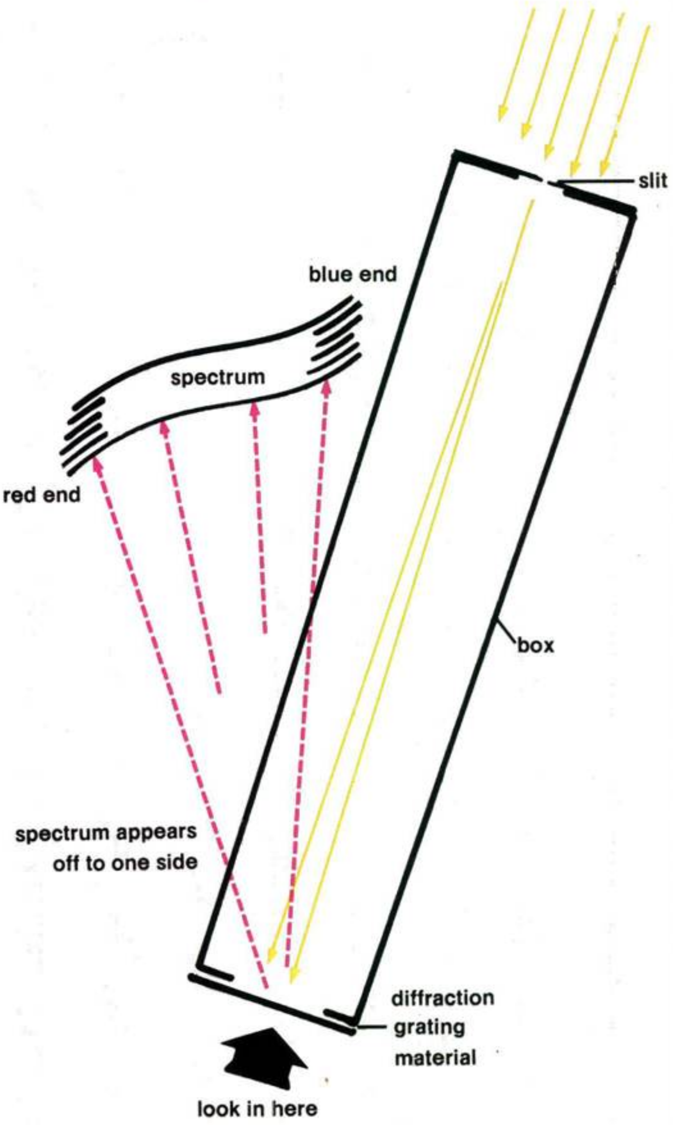
We can determine the constant of proportionality by looking at galaxies of known distances, measuring the redshift of their spectral lines (since the galaxies are receding), and calculating their radial velocities. This relation of distance to velocity of recession is called *Hubble's law.* Its importance becomes apparent when you consider galaxies of unknown distance. We can take the spectra of these galaxies, determine their redshifts, and then use Hubble's law to determine the distances to these galaxies. This method is especially fruitful when galaxies are so far removed that no other method of distance determination can be used.

A Home Built Spectroscope

You can build a simple spectroscope using only a toothpaste carton, some tape, a razor blade and some inexpensive "transmission diffraction grating" — a thin plastic etched with hundreds of parallel grooves per inch — which acts like a prism. Transmission diffraction grating material is available from numerous scientific/educational supply companies, or with luck it can probably be obtained from a local high school physics teacher; about one square inch will do. In the flap on one end of the carton, cut a 1/2 inch long by 1/10 inch wide slot; in the other end cut a circular hole less than an inch in diameter. Place the grating over the circular hole and tape down the corners.

To use your spectroscope, look through the grating into the dark carton, and aim the slot toward any bright source of light. Tungsten light bulbs will show a complete color spectrum, while mercury vapor or sodium type street lamps will show only distinct emission lines of various color — surprisingly different from the tungsten lamp. Try comparing the spectra of street lights, neon signs, fluorescent lamps and other lights you may find. Different sources will reveal different spectra.

The line *shape* arises from the shape of the slit in the carton. If the slit is very narrow, the spectrum will be sharp but dim; if it's wide, the lines will be wide. To see the dark lines in the solar spectrum, the slit should be quite thin. Your simple spectroscope actually uses the same basic principles as some of the world's finest astronomical instruments, including the Solar Tower telescope at Sacramento Peak Observatory, the McMath telescope at Kitt Peak National Observatory, and even the Apollo Telescope Mount which flew on board Skylab.


slit
blue end
spectrum
red end
box
spectrum appears off to one side
diffraction grating material
look in here

Spectroscopy has been crucial in distance determination for the most distant of objects — quasars (also called QSOs). Quasar spectra were quite puzzling at first. Emission lines were present but could not be identified as any known element. After some time, though, Jesse Greenstein and Sandage suddenly realized these lines actually belong in the ultraviolet part of the spectrum (which is normally not visible from Earth's surface), and had been redshifted into the visible by the enormous recessional velocity of the QSO. Typical velocities are 15 to 30 percent the speed of light which, using Hubble's law, implies that quasars must be billions of light-years distant! Astronomers continue to collect and study QSO spectra hoping to find insights into the physical nature of these enigmatic objects.

The avalanche of modern discoveries set off by new, large telescopes and sensitive electronic light detectors isn't going to stop. So much is happening today that even professional astronomers can hardly keep up with the technical articles appearing in journals and observatory publications. Spectroscopy plays an important role in much of this ongoing prediscovery because only spectra — whether in visible light, ultraviolet, infrared, radio or x-ray — can provide so much data about the conditions and composition of an object. ASTRONOMY will continue to bring you reports on the findings of this incredibly diverse and powerful technique — astronomical spectroscopy.

Dr. Robert Stencel is an astrophysicist working at the Johnson Spaceflight Center in Houston, Tex. His current research interests include ultraviolet stellar spectroscopy and astroarcheology - especially the 1,000 year old site at Angkor Wat in Cambodia and its treatment during the recent war. Susan Conat-Stencel is a journalist with special interests in science writing, and Bill Blair is an astronomy graduate student at the University of Michigan.

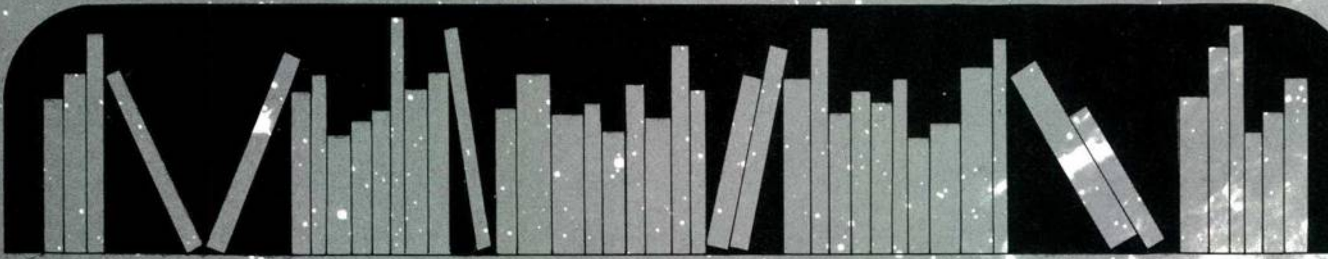
Moon and Earth

Earth and its moon are only tiny specks swimming in the vast blackness of space — something we all need to remember from time to time. Our planet — our speck — shines in brilliant blues and greens, glinting from land and ocean surfaces, with patches of duller oranges, yellows and browns revealing vast lifeless desert areas. Dazzling white clouds move in the shifting patterns of climate and weather, atmospheric systems moving water and heat around the globe. In contrast to Earth, the moon is the dark gray-brown rock exposed to unattenuated solar radiation and light for billions of years. Faintly visible are vast lava filled scars blasted by the final formative collisions of primordial material.

On Sept. 18, 1977, a powerful telephoto camera aboard NASA's Voyager 1 spacecraft, bound for a 1979 rendezvous with Jupiter, was aimed toward Earth. It took three pictures through different color filters and beamed them back to Earth via the main spacecraft antenna. The images were combined into this single color picture at the Jet Propulsion Laboratory in Pasadena, Calif.; it is the first picture ever taken from deep space that shows Earth and the moon together. At the time the picture was made — 13 days after launch — Voyager was over seven million miles (11 million kilometers) from Earth. Because Voyager used a telephoto lens to make the picture, and JPL scientists further enlarged the image, it is a 100 power close-up. To see Earth and the moon as they would have looked to a human riding the spacecraft, you'll have to prop the page up, walk about 100 feet (30 meters) away, and then look back. Seen in the proper perspective, the remoteness and isolation of our world is almost frightening.

The moon appears close to Earth because at the time the picture was made, the moon was almost in line with the spacecraft. To the inhabitants of Earth, it was a few days past full. If the picture had been taken a week earlier or later, the moon could have appeared up to three feet (one meter) to the left or right of Earth at the scale this picture is printed. And if you do walk away to see the picture in correct perspective, remember that the moon would be about three feet closer to you than Earth is. On this same scale, you are some 400 meters (the length of four football fields) from the sun.

NASA's Voyager spacecraft is intended to make high resolution pictures of Jupiter and its moons, and sense the magnetic and particle environment around Jupiter in March 1979. It will then continue on to Saturn for a similar encounter in November 1980.



ASTRONOMY REVIEWS

The Universe

produced for NASA by GRAPHIC FILM CORP. (1976)

28 minutes color free rental
distributed by NASA Film Libraries

The wonder, mysteries, violence and glory of the cosmos are all set before the viewer in **The Universe**, a 28 minute color film. As stated early in the picture, the film "explores almost inconceivable extremes of size and time from the vast islands of stars called galaxies, to subatomic particles; from cosmic events that occurred billions of years in the past to microcosmic events in the present that endure for only a billionth of a second."

Happily, the producers of this film have chosen to realize their conception not with stock observatory photos, but with original artwork and animation that dramatizes, rather than merely illustrates, various aspects of the universe. Viewers can watch a supernova explosion occurring, instead of having to stare at a photo of the Crab nebula. The film's text, well-written and concise (and presented in a fine, low-key narration by William Shatner), provides an excellent introduction to the subject for lay audiences, and educates as well as entertains.

Artwork and visual effects throughout most of the film are stunningly achieved; particularly breathtaking is a shot that scans up from the solar system's position in our galaxy's spiral arm to a perspective along the galactic plane toward the distant nucleus. Also effective are realizations of the big bang and stellar evolution. It is a pity, therefore, that the section devoted to the solar system suffers badly by comparison (at least in the visual element); the mountains and canyons of Mars have a modeling clay look, while the surface of Pluto resembles nothing more than a coral sponge. The film is obviously slightly out of date (it was completed just before the Viking landings on Mars) — but that is an occupational hazard of virtually every film or text produced in the field today, what with the ongoing "information explosion" currently taking place.

But minor quibbles aside, **The Universe** is an exciting and thought provoking film to experience, and is highly recommended. *Henry J. Phillips.*

◆

New Guide to the Moon

by PATRICK MOORE

320 pages, hardcover, $10.95
W.W. Norton & Company, Inc. (1976)

Here is the latest version of a classic book that has been a companion of moongazers for more than 25 years. Written by the well-known British writer and observer Patrick Moore, it is considered by many to be the best of his many works on astronomy and space.

Our understanding of the moon has changed drastically since the dawn of the Space Age, and as expected is clearly reflected in this new edition. The author tells us: ". . . Apollo has come and gone, bringing a complete revolution in our ideas about the moon. I have therefore rewritten the book completely, and reverted to the original title — though practically nothing of the first edition text is left!" (The last revision of this work appeared under the title, **Survey of the Moon**).

One very important thing hasn't changed about this book: It's still written from an observer's viewpoint by a man who knows the lunar surface as do few others. This sets it aside from most other recent publications about our satellite and makes it an invaluable reference for the astronomy enthusiasts.

Moore is one of the most experienced visual observers of the moon alive today. He is currently director of the British Astronomical Association's lunar section and works with a 15 inch reflector in his private observatory in Selsey, England. In the 1950s, he co-authored (with the late Dr. H.P. Wilkins) the famous volume **The Moon**, which contained Wilkins' great 100 inch diameter lunar map.

Not surprisingly then, the most fascinating and valuable parts of **New Guide to the Moon** are those dealing with actual observation of its surface with smaller instruments. Everything from theories of crater formation to the Apollo explorations can be found in this book, making it a comprehensive introduction to our nearest neighbor in space. But its greatest use and charm lies in its vividly detailed description of the lunar surface, and in pointing out those areas where today's astronomy enthusiasts can still do useful work.

The observer can hardly expect to contribute something of value to our knowledge of the moon by attempting to map it with a small telescope from his backyard as in days gone by. On the other hand, a study of "Transient Lunar Phenomena" could prove of great importance. A careful systematic patrol for "activity" in features like Aristarchus, Alphonsus, Gassendi, Grimaldi and Plato (to name only a few of the moon's many apparently active areas) can be a fascinating and rewarding experience. Colorations, obscurations, flashes and moving lights are just some of the things that have been reported over the centuries by amateur and professional lunar observers alike. And even negative observations can have value as in other areas of science.

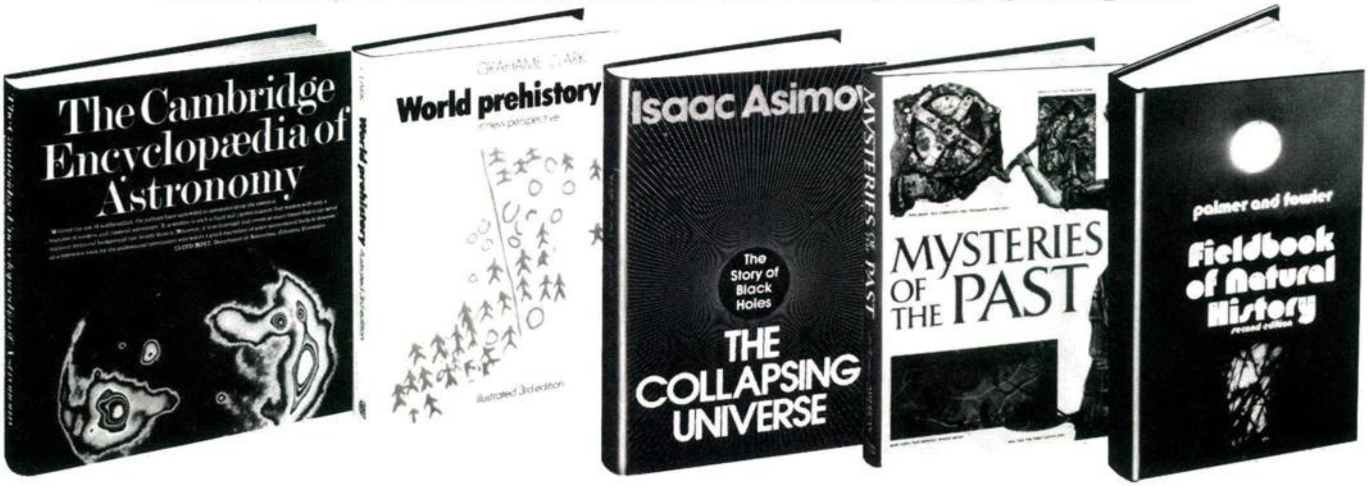
For many kinds of lunar observation (eclipses, occultations, etc.), an instrument as small as a two or three inch telescope is quite sufficient. For patrol work, however, Moore prefers a scope of at least eight inches aperture. Another important requirement is that the observer be as familiar as possible with those features he is watching — especially under varying conditions of lighting and libration.

To this end, this book contains a superb description of the entire visible surface of our satellite, arranged by quadrants and with accompanying detailed maps. Covering more than 70 pages, this section alone is well worth the price of the book! It serves as an ideal tourguide for those who wish to learn their way about the ghostly surface of our satellite. This makes an excellent first project if you're just beginning your telescopic exploration of this fascinating world.

Observing is truly the life-blood of astronomy enthusiasts — whether it be the moon and planets or clusters and nebulae. The moon itself is the best place to start. As it serenely sails the ocean of night, it beckons our attention. And as we travel there in our telescopic spaceship, we will find no better companion than **New Guide to the Moon**! *James Mullaney.*

◆

Black holes, quasars, and pulsars... the origins and future of the universe... the geology of the Red Planet... how to read the stars...



Sooner or later all the secrets of the natural world are revealed to the members of the

Natural Science Book Club

(Publishers' Prices shown)

61660. MECHANICS OF THE MIND. *Colin Blakemore.* Reports on the latest research on the human brain—from why we sleep to how we remember. Illustrated. **$19.95**

73240. QUASARS, PULSARS, AND BLACK HOLES. *Frederic Golden.* A thorough review of the spectacular discoveries in astronomy. Illustrated with twelve drawings and twenty-four color photographs. **$7.95**

39560. COLONIES IN SPACE. *T. A. Heppenheimer.* Illustrated account of how space will be colonized. **$12.95**

55125. IN THE DESERTS OF THIS EARTH. *Uwe George.* "A remarkable account of the world's most desolate places, told with spine-tingling delectation."—*Kirkus Reviews.* Full-color photographs. **$14.95**

87111. WHITNEY'S STAR FINDER. *Charles A. Whitney.* A top-notch field guide to the night sky shows you how to locate and observe stars, planets, comets and eclipses. **$5.95**

48601. THE FIRST THREE MINUTES/THE COLLAPSING UNIVERSE. Fascinating tour of the universe through its expansion and evolution. *Plus,* the investigation of the most mystifying of astronomical phenomena—the black hole. *The 2 count as one book.* **$17.90**

34665. ASTRONOMY: Fundamentals and Frontiers. *Robert Jastrow and Malcolm Thompson.* An extraordinary tour of modern astronomy with over 330 illustrations. **$15.50**

62920. MONUMENTS OF CIVILIZATION—THE ANDES. *Roberto Magni and Enrico Guidoni.* Breathtaking tour of the early South American civilizations. Over 100 full-color photographs. Outsized. **$25.00**

87890-2. WORLD PREHISTORY IN NEW PERSPECTIVE. *Grahame Clark.* Tour of man's pivotal rise from the stone age to the dawn of civilization. Examines Egyptians, Mayas, Babylonians, Hittites and many others. *Counts as 2 of your 3 books.* **$29.95**

48475. FIELDBOOK OF NATURAL HISTORY. *E. Laurence Palmer and H. Seymour Fowler.* With over 800 illustrations, it explores all major plant and animal species and most rocks and minerals. **$17.50**

86760. WHAT IS THE WORLD MADE OF? *Gerald Feinberg.* A layman's introduction to the fascinating world of particle physics. **$10.00**

Take any 3 books (values to $57.85) for only 99¢ each

if you will join now for a trial period and agree to take 3 more books—at handsome discounts—over the next 12 months.

77050. SCIENTISTS CONFRONT VELIKOVSKY. *Edited by Donald Goldsmith.* Carl Sagan and others take a level look at the controversial views of Immanuel Velikovsky. **$8.95**

43085. EARTH'S AURA. *Louise B. Young.* Grand tour of the atmosphere from man's first crude efforts to pierce the "nothingness," to the latest discoveries about its endangered ozone layer. Fully illustrated. **$12.95**

63340-2. MYSTERIES OF THE PAST. Beautifully illustrated volume explores the riddles of past civilizations. *Counts as 2 of your 3 books.* **$34.95**

37211. THE CAMBRIDGE ENCYCLOPAEDIA OF ASTRONOMY. Huge, definitive work covers everything from the life and death cycles of the stars to the origin and fate of the cosmos. Lavishly illustrated. *Counts as 2 of your 3 books.* **$35.00**

MEMBERSHIP BENEFITS ● In addition to getting three books for only 99¢ each when you join, you keep saving substantially on the books you buy. ● If you continue membership past the trial period, you will be eligible for our Bonus Book Plan, with savings of at least 70% off publishers' prices. ● At 3-4 week intervals (15 times per year) you will receive the Book Club **News**, describing the coming Main Selection and Alternate Selections, together with a dated reply card. In addition, up to 4 times a year, you may receive offers of special selections, always at substantial discounts. ● If you want the Main Selection, or the special selection, do nothing and it will be sent to you automatically. ● If you prefer another selection, or no book at all, simply indicate your choice on the card, and return it by the date specified. ● You will have at least 10 days to decide. If because of late mail delivery of the **News,** you should receive a book you do not want, we guarantee return postage.

55000. THE ILLUSTRATED ENCYCLOPEDIA OF ASTRONOMY AND SPACE. Covers the full range of astronomical knowledge and space exploration. **$16.95**

49267. FRONTIERS OF ASTROPHYSICS. *Edited by Eugene Avrett.* A compilation by 12 distinguished scientists on the latest developments in astrophysics, from solar research to neutron stars and intergalactic matter. **$20.00**

70157. PRINCIPLES OF COSMOLOGY AND GRAVITATION. *Michael Berry.* A fascinating description of the universe as revealed by observation, presenting the current theoretical framework for its construction. **$16.95**

79715. SPACE AND TIME IN THE MODERN UNIVERSE. *P. C. W. Davies.* Survey of this century's exciting discoveries in physics and chemistry, focusing on the changing ideas of space and time as applied to astronomy and cosmology. **$13.95**

Natural Science Book Club 4-A2A
Riverside, New Jersey 08075

Please accept my application for membership and send me the three volumes indicated, billing me only 99¢ each. I agree to purchase at least three additional Selections or Alternates during the first 12 months I am a member, under the club plan described in this ad. Savings range up to 30% and occasionally even more. My membership is cancelable any time after I buy these three books. A shipping and handling charge is added to all shipments.

3 books for 99¢ each

Indicate by number the books you want.

A few expensive books (noted in book descriptions) count as 2 choices.

Name ____________________

Address ____________________

City ____________________

State ____________ Zip ____________

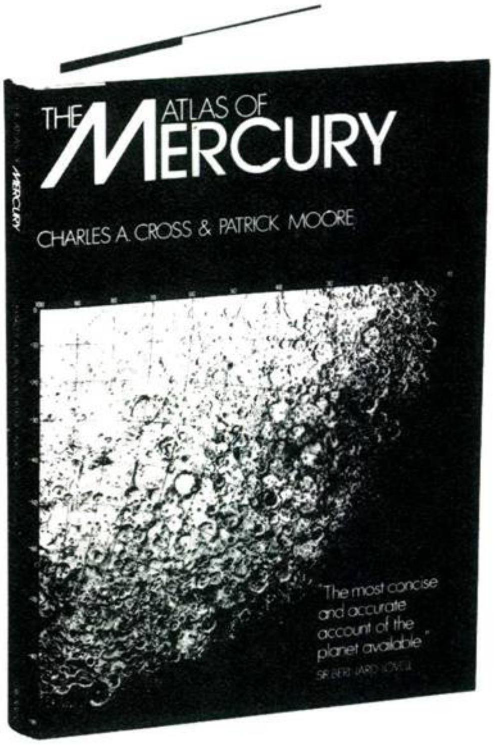
(Offer good in Continental U.S. and Canada only. Prices slightly higher in Canada.)

The Atlas of MERCURY

Now, for the first time, an accurate survey of the small hot planet Mercury is available to you. Mercury defied traditional astronomy: It lay too far away, and was too small for telescopes to reveal much of its true surface. Even its real period of rotation remained unknown. Maps of Mercury, compiled from the best telescopic evidence available before the flight of Mariner 10, bear little resemblance to the devastated surface of craters, scarps, ridges and plains now revealed to us.

By far, **The Atlas of Mercury** is the most up-to-date guide to Mercury published in this generation. It's perfect for students and astronomers alike, with text that examines all aspects of Mercury: its atmosphere, surface conditions, magnetic field, interior, temperature, rotation, hot poles, calendar, and place in the solar system.

The Atlas of Mercury is illustrated throughout — not only with the latest maps of the planets, but with a breathtaking collection of Mariner 10 photographs — and fascinating historical maps, as well!


MERCURY
THE ATLAS OF MERCURY
CHARLES A. CROSS & PATRICK MOORE
"The most concise and accurate account of the planet available"
SIR BERNARD LOVELL

The Atlas of MERCURY

by Patrick Moore and Charles Cross
Actual Size: 9-3/8" x 13"
48 pages

Please send me ________ copies of **The Atlas of Mercury** for $10.00 each, plus 75¢ per copy for shipping and handling. I have enclosed $10.75 for each copy ordered.

Please send check or money order to:

ASTRONOMY
Dept. A-678
411 E. Mason St., 6th Floor
Milwaukee, WI 53202

Please charge to my: ☐ Master Charge
☐ BankAmericard/VISA

Expiration Date ________________

Account Number ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Personal Signature ________________

Name ________________
(please print)

Address ________________

City ________________

State/Prov. ________________ Zip ________________

Please allow 4 to 6 weeks for delivery.

Guide to Back Issues

What did Apollo find on the moon? Where can I find something about making a telescope? What's the big bang all about? When has ASTRONOMY had articles about black holes? If you have questions like these, ASTRONOMY back issues can help you. More than 50 issues of ASTRONOMY have been published, containing fascinating articles, exciting pictures and helpful observing hints that you may have missed. But you don't have to keep on missing them. While supplies last, you can buy ASTRONOMY back issues at the *original price* — just $1.50 each*. Don't wait another moment to order — when supplies are depleted, there won't be more!!!!

August 1973: FIRST ISSUE. "Hour of the Midday Night" (Solar Eclipses); "In Search of Planet X"

March 1974: "The Cosmic Abyss"; "What Happened to Comet Kohoutek?"; "Magnetic Fields Beyond Earth"

July 1974: "Astronomy From Skylab"; "What Radio Eyes Would See"; "An Introduction to Small Telescopes"

May 1975: "The Search for Intelligence"; "Countdown to 2001" (Future of the Space Program); "Comet Exploration from Space"; "The Realm of the Galaxies"

June 1975: "From Dust to Dust" (stellar evolution); "The Changing Surface of Mars"; "The Realm of the Galaxies"; "Rich Field Telescopes"

July 1975: "The Quest for Life on Mars"; "The Age of Nearby Stars"; "An International Space Venture" (Apollo/Soyuz); "Mysteries of the Galactic Core"

August 1975: "Showers of Fire" (Meteors); "Faster Than Light?" (Quasars); "Observing the Perseid Shower"

September 1975: "Baptism of Fire" (Meteor Craters); "The Quasar Dilemma"; "Cosmic Rays"; "Let's Take a Look at the Sun . . . Cautiously"

October 1975: "Aurora"; "Starspots on Betelgeuse"; "Shape of the Milky Way"; "Observing Jovian Detail"

November 1975: "Big Bang to Galaxy"; "Mars' New Frontiers"; "Two X-Ray Stars"; "Find a Comet"

December 1975: "Astronomy From the Moon"; "The Planet Mercury"; "Mars at Opposition"; "Tune Up Your Telescope" (Collimating Optics)

February 1976: "Io"; "Exploding Stars"; "How Far Is Up?" (Stellar Distances); "The Gibbous Moon"

March 1976: "Beyond Space Shuttle"; "Whispers of the Cosmos' Birth" (Cosmic Microwave Background); "Infrared Astronomy"; "Life's Protective Shield" (Magnetic Field Reversal)

April 1976: "Finding Unseen Worlds" (Astrometry); "Dust Clouds and Ice Ages"; "Astrophotography . . . In Spite of Myself"

May 1976: "Quasars: Oddities of Space"; "Cosmic Explosions"; "Comet West"; "Molecules of Life" (Interstellar Molecules); "Choosing B&W Films"

June 1976: "Asteroids"; "Viewing the Full Moon"; "What You Can See Through a Small Refractor"; "Setting Up an Astro-darkroom"

***July 1976:** SPECIAL ISSUE. "The History of American Astronomy"

August 1976: "Venus"; "Viking Orbits Mars"; "Clusters of Galaxy Clusters"; "Exploring the Milky Way, Part 1"; "Red Light Sky Photography"

September 1976: MOON ISSUE. "The Moon's Early History"; "Science on the Moon"; "The Last Quarter Moon"; "Man Looks at Mars"; "Developing B&W Astrofilms"

October 1976: "Radio Interferometry"; "Searching for Mars on Earth"; "Birthplaces of Stars"; "City Astrophotography"

November 1976: "The Space Telescope"; "Mars Pictorial"; "Black Holes, White Holes and Wormholes"; "Doubles, Binaries and Multiple Stars"

December 1976: "The Magellanic Clouds"; "Radar Astronomy"; "Red Giant Stars"; "Printing Your Astrophotographs, Part 1"; "The Messier Catalog"

January 1977: MARS ISSUE. "Viking on Mars: Exciting Results"; "Life on Mars: Ambiguous Results"; "Printing Your Astrophotographs, Part 2"; "Exploring the Milky Way, Part 2"

February 1977: "Uranus and Neptune"; "Pluto"; "Miniblack Holes"; "Observing Saturn"; "Cold Cameras, Part 1"

March 1977: "Phobos and Deimos"; "New Color Photos of Galaxies"; "Duststorms of Mars"; "Cold Cameras, Part 2"

April 1977: "Supernovae!"; "Astronomers in Space, Part 1"; "Printing Your Astro-Photographs, Part 3"; "Building a Six Inch Reflector, Part 1"

May 1977: "The End of Time"; "Can Life Evolve in Elliptical Galaxies?"; "Building a Six Inch Reflector, Part 2"; "Astronomers in Space, Part 2"

June 1977: "Gamma Rays and the Origin of Cosmic Radiation"; "A Second Ringed Planet"; "Beginning With Your Telescope"; "Observing With Binoculars"

July 1977: "The X-Ray Universe"; "What Makes Novae Blow Up?"; "Tracking Asteroids"; "Astrophotography With Telephoto Lenses"

August 1977: "Slow Boat to Centauri" (Interstellar Travel); "Probing the Nearest Star"; "Does the Universe Oscillate?"; "Building a Six Inch Reflector, Part 3"

September 1977: "Stars With Companions"; "Robot Probes"; "Between Stars and Space"; "Building a Six Inch Reflector, Part 4"; "Light Pollution"

October 1977: MARS ISSUE. "The Polar Regions of Mars"; "Martian Climate"; "Rich Clusters of Galaxies"; "Buyers Guide to Small Telescopes"

November 1977: "The Revolution in Astronomy"; "The Southern Sky"

December 1977: "Why Do Planets Have Rings?"; "Tunguska — Collision With a Comet"; "Learning the Constellations, Part 1"; "Printing Your Astrophotographs, Part 4"

$1.50 per copy
***Special July 1976 issue $3.50 per copy**
For Postage & Handling:
U.S. — Add $1.00 per order
Canada/Mexico — Add $2.00 per order
All Other Foreign — Add $2.50 per order

- ☐ **August 1973**
- ☐ **March 1974**
- ☐ **July 1974**
- ☐ **May 1975**
- ☐ **June 1975**
- ☐ **July 1975**
- ☐ **August 1975**
- ☐ **September 1975**
- ☐ **October 1975**
- ☐ **November 1975**
- ☐ **December 1975**
- ☐ **February 1976**
- ☐ **March 1976**
- ☐ **April 1976**
- ☐ **May 1976**
- ☐ **June 1976**
- ☐ **July 1976**
- ☐ **August 1976**
- ☐ **September 1976**
- ☐ **October 1976**
- ☐ **November 1976**
- ☐ **December 1976**
- ☐ **January 1977**
- ☐ **February 1977**
- ☐ **March 1977**
- ☐ **April 1977**
- ☐ **May 1977**
- ☐ **June 1977**
- ☐ **July 1977**
- ☐ **August 1977**
- ☐ **September 1977**
- ☐ **October 1977**
- ☐ **November 1977**
- ☐ **December 1977**

I am enclosing $1.50 for each back issue ordered ($3.50 for July 1976), plus the appropriate postage for the order.

Total enclosed: $__________

Send check or money order to:

ASTRONOMY
411 E. Mason St. — 6th Floor
Milwaukee, WI 53202

Date: _______________

Payment must accompany your order.

Name ____
(please print)

Address ____

City ________________ **State/Prov.**____________ **Zip**________

Allow 6-8 weeks for delivery

SKY ALMANAC

Asteroids at Opposition, Planets in Conjunction

For those of you who like to do your observing in the early evening hours, the skies of June provide the perfect opportunity. Just after sunset, Venus lights up the night sky, followed by Jupiter, Mars and Saturn. During the first two weeks of the month, the moon passes close to each of these planets. This might make an attractive series of photographs for an enterprising astrophotographer. On the 4th, there is a rare conjunction of Mars and Saturn — only 1/10 degree apart! Should you feel inclined to do something other than planetary observing, two of the "big four" asteroids, Pallas and Vesta, reach opposition on the same night. And add to all this the eagerly awaited arrival of summer on the 21st — which should totally banish memories of observing in the snow and cold of last winter. Now, if only it wouldn't rain....

Mercury

Mercury is doing its disappearing act this month. The planet is at superior conjunction (on the other side of the sun from Earth) on the 14th, so it will be too close to the sun to be seen all month. But take heart: Next month the planet will be at greatest eastern elongation (appearing in the western sky). With some determination, clear skies and a little luck, you'll be able to catch it then.

Venus

When comparing Venus and Jupiter, it has been said that Venus is "the pearl of great price" while Jupiter is "the pearl of lesser price". Perhaps for June, a more appropriate analogy for Venus is that of a diamond. At magnitude -3.5, Venus dominates the western sky after sunset with 80 percent of the planet's disk illuminated by sunlight. At sunset the planet is about 26 degrees above the western horizon and is easily visible as the first "star" in the evening twilight. On the 8th, the slim crescent of the moon (three days past new) will pass seven degrees south of Venus, giving you a good excuse to haul out your camera to photograph the pair.

During June, Venus moves south of Castor and Pollux, setting 2-1/2 hours after sunset. On the 10th, it is five degrees south of Pollux.

In a small or medium sized telescope, Venus is devoid of detail. The planet is shrouded in hazelike atmosphere believed to be composed of droplets of sulfuric acid. This haze makes Venus highly reflective, but it masks any detail on the planet. During the month, the distance between Earth and Venus increases from 125 million miles (200 million kilometers) to 107 million miles (171 million kilometers).

Mars

Not to be outdone by Venus, Mars has a special event of its own during the month. On the 4th, the red planet passes 1/10 degree south of Saturn. (For diagrams of the event, see the May 1978 Sky Almanac.) The moment of minimum separation occurs around 8 p.m. EDT (5 p.m. PDT), so it's a good idea to set up your observing and/or photographic equipment shortly after sunset. Mars is a fast moving planet, so timing is very important. Closest approach occurs before sunset on the west coast, so by the time the pair sets around midnight, Mars will already be pulling away from Saturn. It would be worth your while to view the planets a few days before and after the conjunction date, as they approach and pull away from one another. On the 2nd, Mars is seven degrees west of Saturn and on the 3rd, it is 1/2 degree west of Saturn. The same separations occur after the conjunction with Mars positioned 1/2 degree southwest of Saturn on the 5th and seven degrees southwest of Saturn on the 6th. A conjunction of this sort takes place every 2 years 23 days, and is a definite must for astrophotographers.

Mars isn't very spectacular to look at this month. The planet is at magnitude 1.5 and has a diameter of only five seconds of arc. About 91 percent of the planet's disk is illuminated, but because the image is so small, no details are discernable.

You can find Mars high in the southwestern sky at sunset; it sets about four hours later. During the month, Mars' distance from Earth increases from 152 million miles (243 million kilometers) to 173 million miles (277 million kilometers).

Jupiter

This is the last month you'll be able to view Jupiter in the evening sky this year. In July it is too close to the sun to be seen, and in August it appears in the morning sky. Still, our solar system's largest planet is an impressive sight shining in the western sky at magnitude -1.4 in the evening twilight.

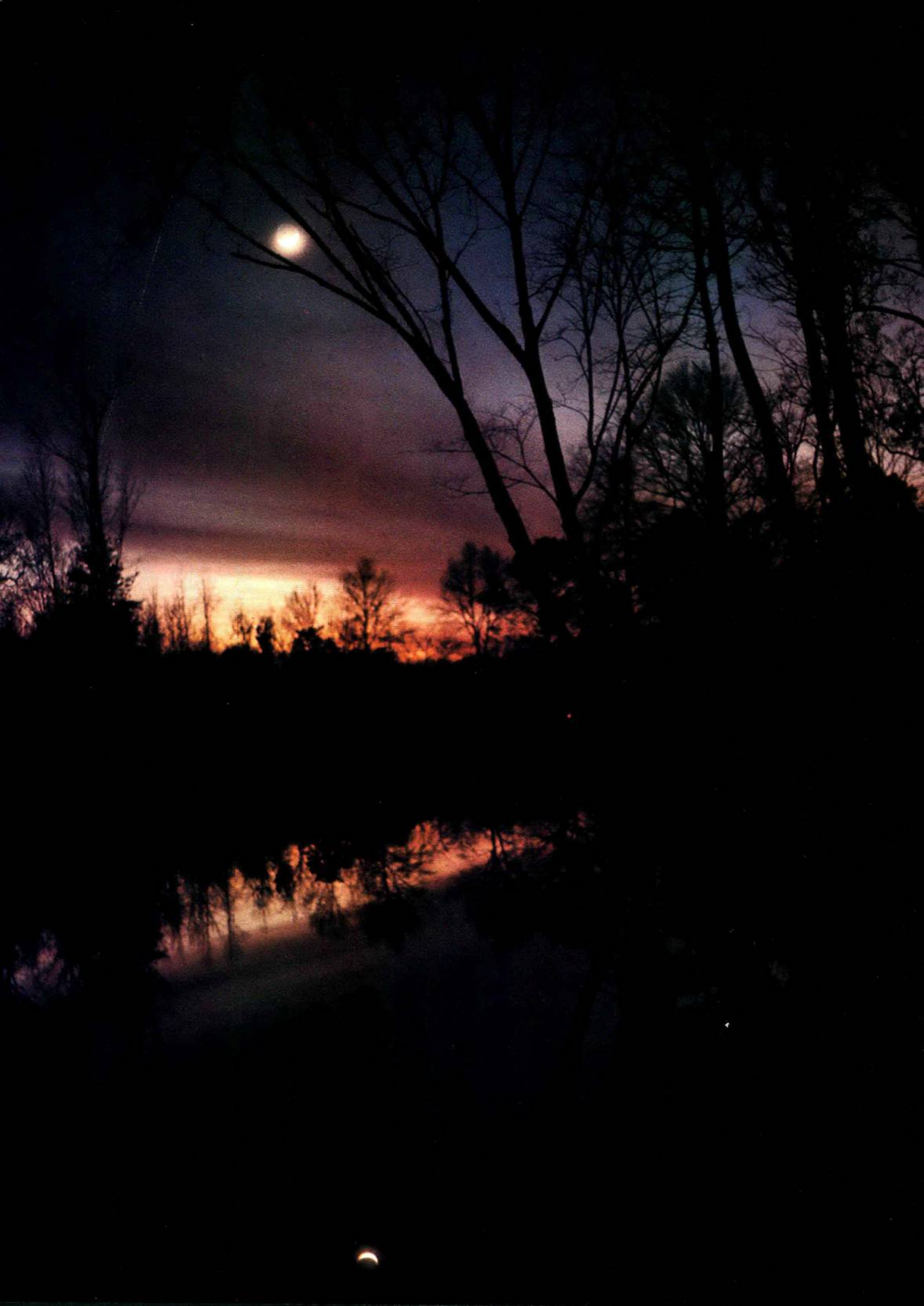
Jupiter sets about 1-1/2 hours after sunset, so you'll have a difficult time trying to observe its cloud bands or the four (of its 13) moons that closely orbit the planet. It's easier to catch the moons if you look early in the month; by the end of June, they will still be visible, but twilight's glow will make it more difficult to spot them.

Jupiter is located in Gemini, near the feet of the twins. On the 7th, the moon (two days past new) will pass five degrees south of Jupiter — an attractive sight in the glow of sunset.

Saturn

Highlighting Saturn's performance this month is its conjunction with Mars on the 4th (see the Mars section); the two planets will be separated by 1/10 degree. Saturn measures 15 seconds of arc and is at magnitude 0.8, slightly

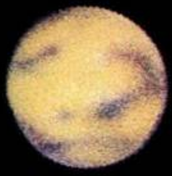
The 1.8 day old moon is silhouetted against wispy clouds and the deepening colors of evening twilight. The equipment and procedure used are relatively simple: a Canon FX camera with a 50mm f/1.8 lens for this one second exposure on Fujichrome 100 film. Photograph by L.H. Price.



Planet Finder

Ⓒ Ceres

June	1	15
R.A.	19^h43^m	19^h36
Dec.	-26°16'	-27°30'
Mag.	+7.3	+7.2



Ⓐ Mercury

June	1
R.A.	3^h31^m
Dec.	+17°37'
Mag.	-0.7

Ⓑ Mercury

June	15
R.A.	5^h34^m
Dec.	+24°19'
Mag.	-1.8

Ⓜ Mars

June	1	15
R.A.	9^h43^m	10^h11^m
Dec.	+15°12'	+12°26'
Mag.	+1.4	+1.5

Ⓝ Neptune

June	15
R.A.	17^h03
Dec.	-21°17
Mag.	+7.7

SUN

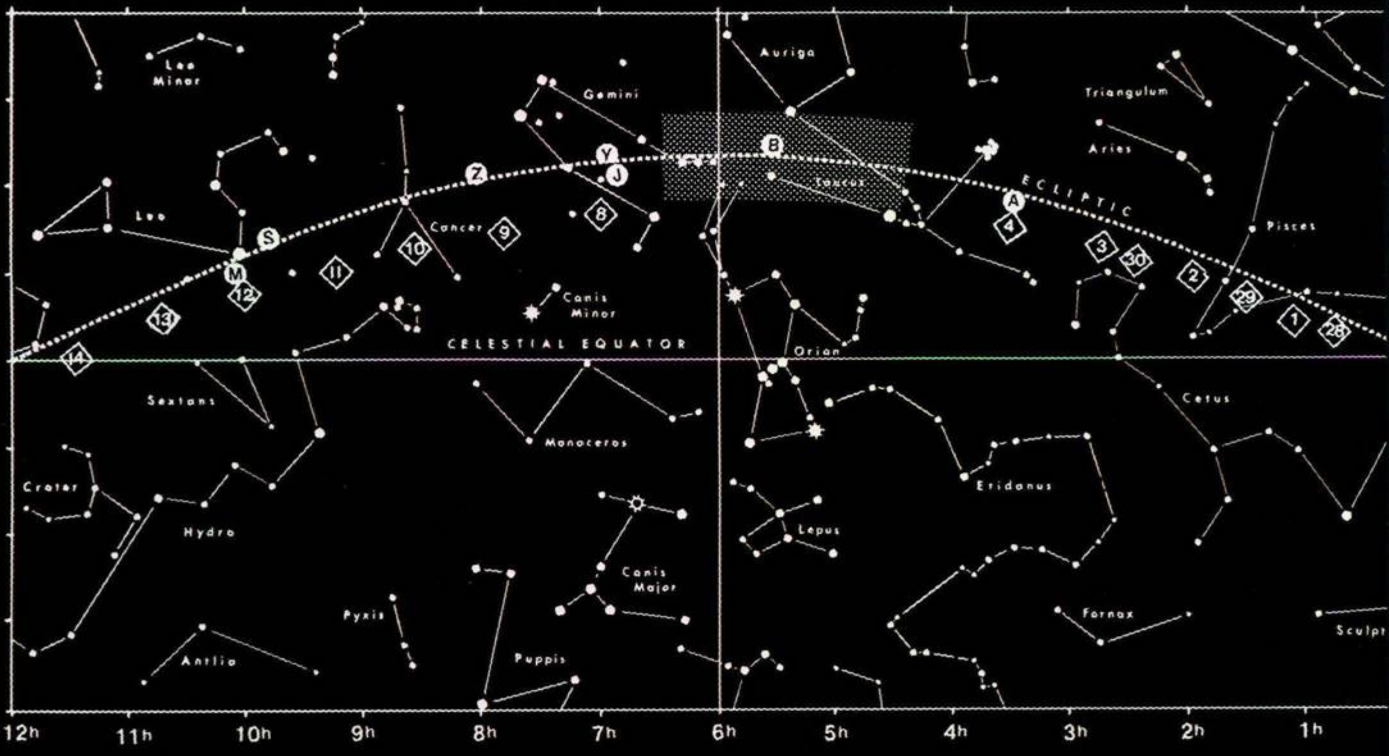
The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

Ⓢ Saturn

June	1	15
R.A.	9^h50^m	9^h54^m
Dec.	+14°38'	+14°17'
Mag.	+0.8	+0.8

Ⓤ Uranus

June	15
R.A.	14^h42^m
Dec.	-15°19'
Mag.	+5.7



Leo Minor
Gemini
Auriga
Triangulum
Aries
Leo
Cancer
Taurus
ECLIPTIC
Pisces
Canis Minor
CELESTIAL EQUATOR
Orion
Sextans
Cetus
Monoceros
Crater
Eridanus
Hydra
Lepus
Canis Major
Pyxis
Fornax
Sculpt
Antlia
Puppis
Z
Y
J
B
A
S
M
1
2
3
4
8
9
10
11
12
13
14
28
29
30
12h
11h
10h
9h
8h
7h
6h
5h
4h
3h
2h
1h

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec . = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag . = magnitude, a

June 1978

Ⓥ Vesta

June	1	15
R.A.	16h56m	16h42m
Dec.	-15°35'	-16°09'
Mag.	+5.6	+5.5

Ⓙ Jupiter

June	1	15
R.A.	6h39m	6h52m
Dec.	+23°12'	+22°59'
Mag.	-1.4	-1.4

Ⓨ Venus

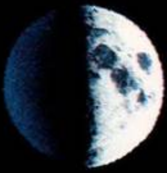
June	1
R.A.	6h52m
Dec.	+24°38'
Mag.	-3.4

Ⓩ Venus

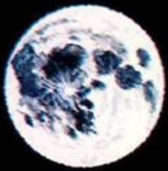
June	15
R.A.	8h04m
Dec.	+22°21'
Mag.	-3.5

Ⓟ Pluto

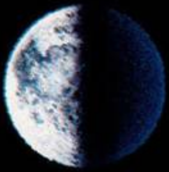
June	15
R.A.	13h16m
Dec.	+10°36'
Mag.	+14



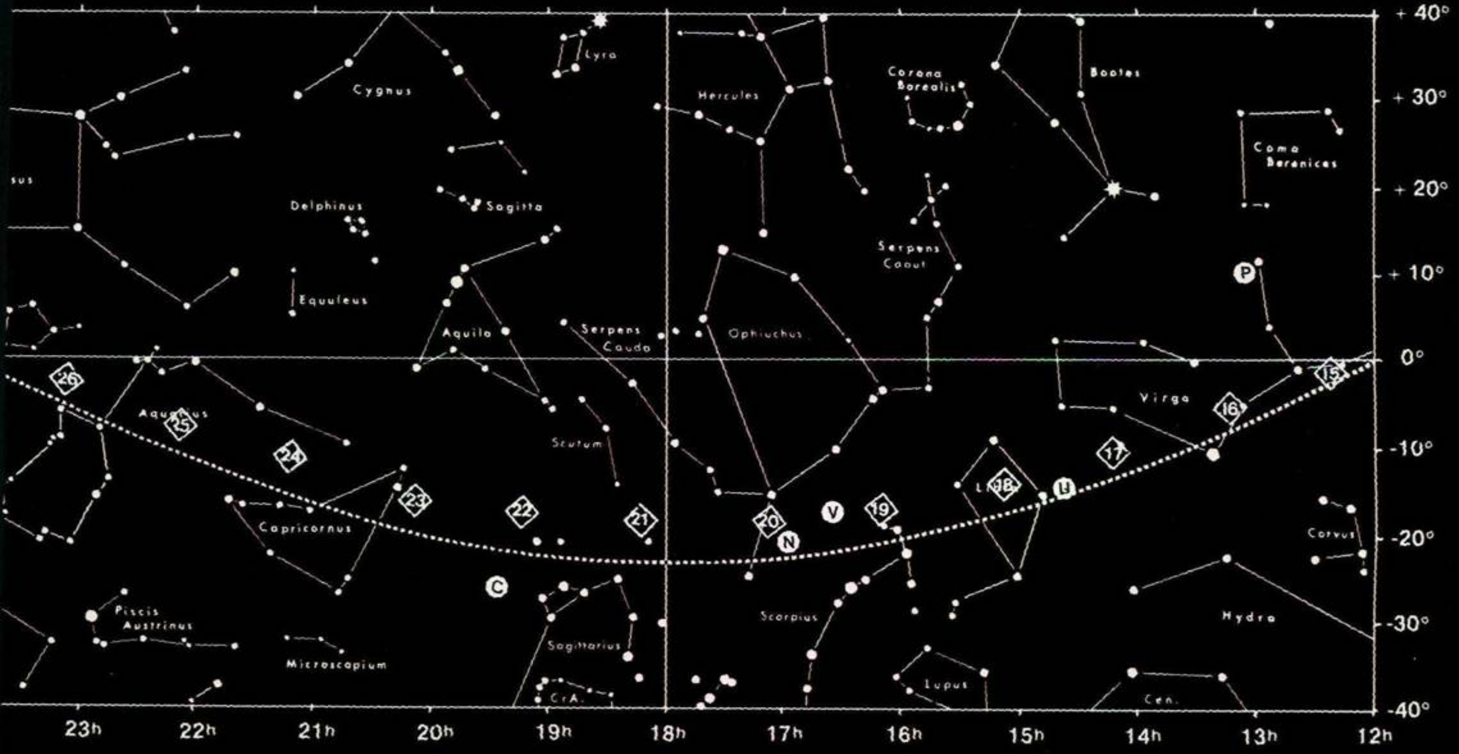
First Quarter
June 13



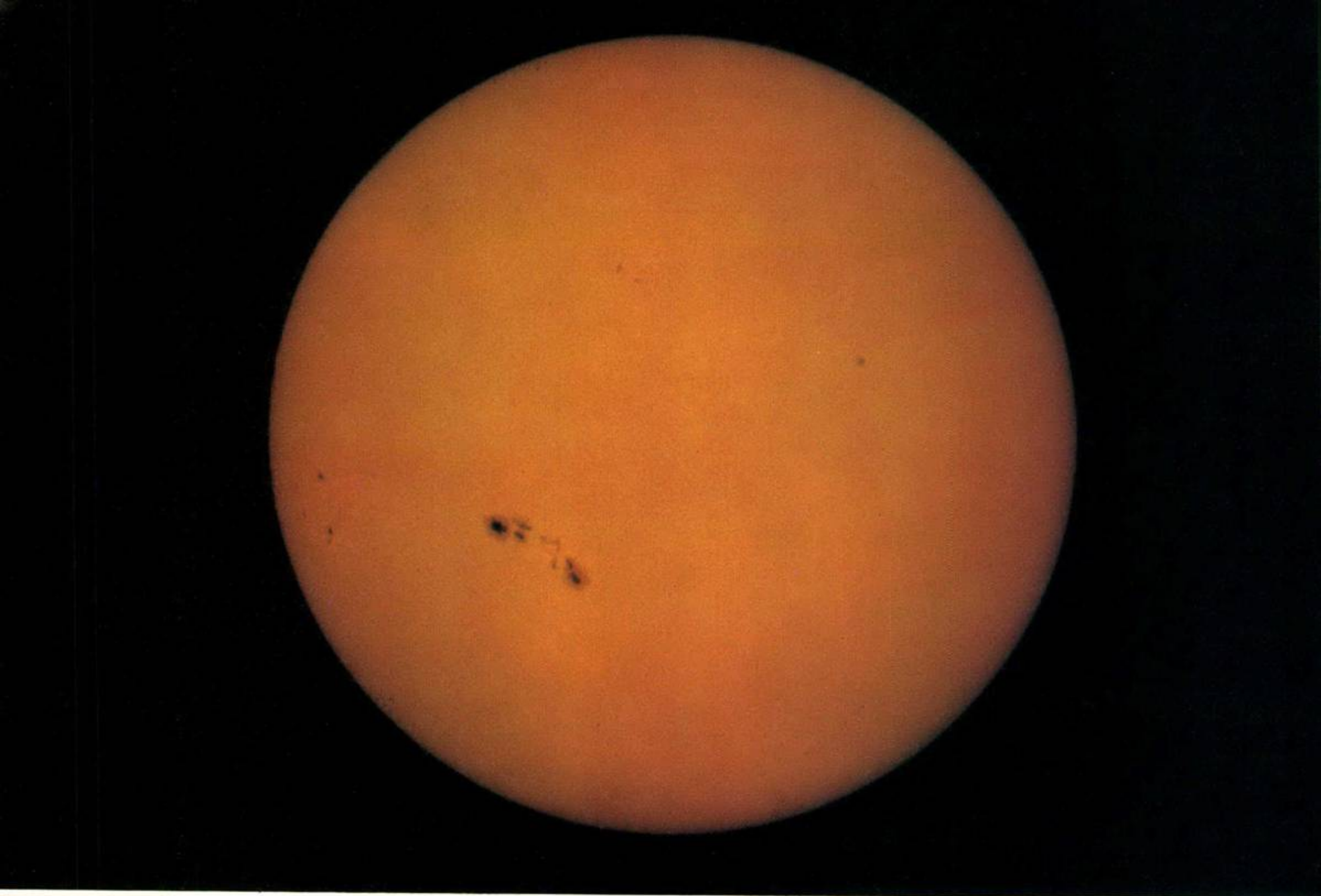
Full Moon
June 20

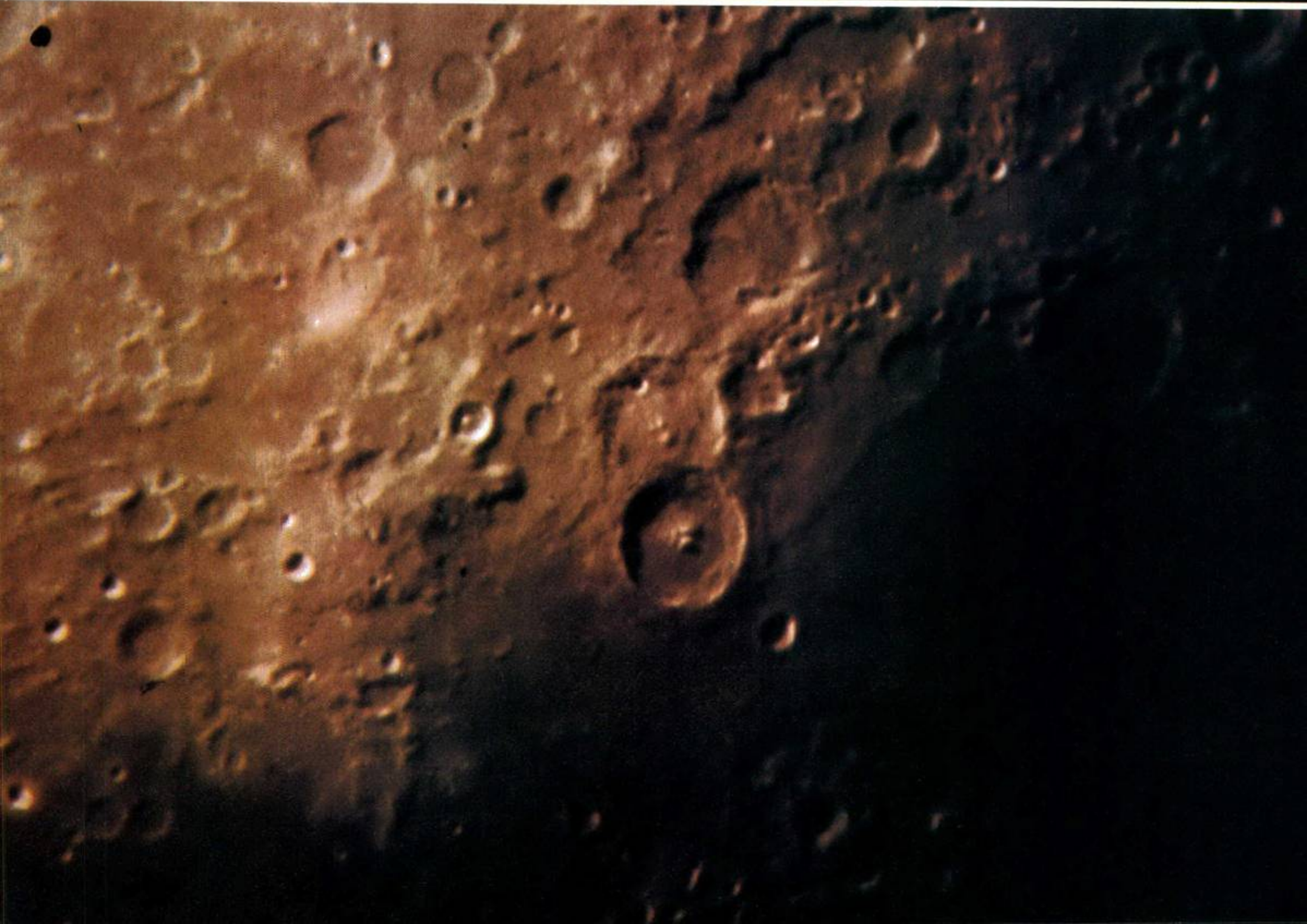


Last Quarter
June 27


Lyra
Cygnus
Hercules
Corona Borealis
Bootes
Coma Berenices
sus
Delphinus
Sagitta
Serpens Caput
Equuleus
Aquila
Serpens Cauda
Ophiuchus
Virgo
Aquarius
Scutum
Libra
Capricornus
Corvus
Scorpius
Hydra
Piscis Austrinus
Sagittarius
Microscopium
Lupus
CrA.
Cen.
P
V
N
C
U
15
16
17
18
19
20
21
22
23
24
25
26
+40°
+30°
+20°
+10°
0°
-10°
-20°
-30°
-40°
23h
22h
21h
20h
19h
18h
17h
16h
15h
14h
13h
12h

measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.





less than one magnitude brighter than Mars. As with the planets already mentioned, the moon (nearing first quarter) passes five degrees south of Saturn on the 11th. On that same night, Mars will be close to both of them, four degrees north of the moon.

Saturn is located in Leo, west of Regulus. It's high in the southwest at sunset and sets about four hours later. During the month, the ringed planet's distance from Earth increases from 880 million miles (1,409 million kilometers) to 920 million miles (1,470 million kilometers).

Uranus

Uranus is in a good position for viewing since it was at opposition last month. The planet is situated in Libra west of the star Alpha Librae, also known as Zubenelgenubi (impress your friends with that one!). Uranus "shines" at magnitude 5.8 and spans 3.9 seconds of arc. In a telescope the planet looks like a small greenish disk and does not have any distinct features. Uranus' atmosphere has much in common with those of Jupiter, Saturn and Neptune — they all consist mostly of hydrogen and helium. On the 17th, look for the waxing gibbous moon to pass three degrees north of Uranus.

Neptune

Neptune reaches opposition on the 7th. The planet may be rather difficult to spot because it's currently located in the southern portion of Ophiuchus, amid the star studded Milky Way. The planet measures 2.4 seconds of arc in diameter and has a magnitude of 7.7. In a telescope, Neptune can be distinguished from the surrounding stars by its unique color: bluish-green. For those of you who like a real challenge, the moon (one day before full) will pass three degrees north of Neptune on the 19th. If you can find it, you're pretty sharp!!

Pallas and Vesta

Two of the "big four" asteroids come to opposition this month — Pallas at 6 p.m. EST on the 4th, and Vesta at 7 p.m. EST on the 5th. (Ceres and Juno reach opposition in July; for more background information, see Gazer's Gazette, May 1978.)

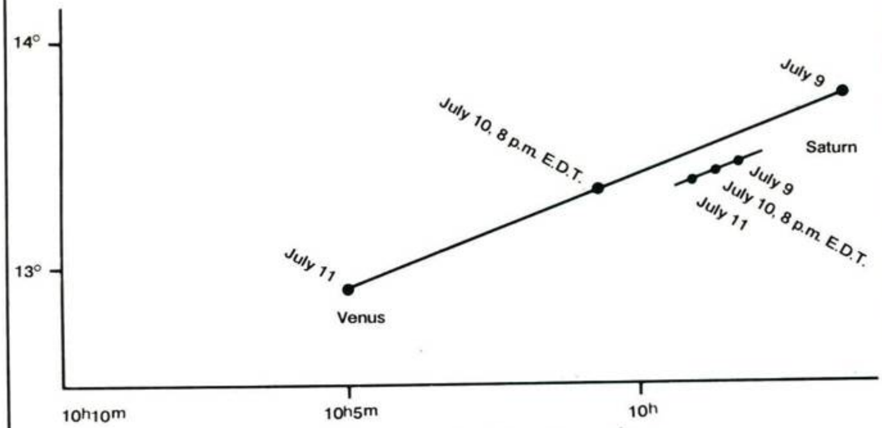
At opposition, Pallas is at magnitude 8.9 and is retrograding through the southern portion of Hercules. The asteroid is 380 miles (610 kilometers) in diameter — the 2nd largest of the big four. With its 35 degree orbital inclination, Pallas is as far away as 50 degrees north of the ecliptic.

At opposition, Vesta (magnitude 5.5) is the brightest of the asteroids. It is retrograding through the southern portion of Ophiuchus, situated north of Neptune and south of Pallas. Vesta is 330 miles (530 kilometers) in diameter. During the month you should be able to locate it with the naked eye, but if that doesn't work, binoculars or a small telescope should insure your success.

Upcoming Events for July

1 Pluto stationary
2 Moon passes 0.8 degrees north of Aldebaran
5 New Moon
9 Moon passes 4 degrees south of Venus and Saturn
Ceres at opposition
10 Jupiter in conjunction with sun
Venus 0.1 degree north of Saturn
Moon passes 2 degrees south of Mars
11 Venus 1.1 degree north of Regulus
13 First Quarter Moon
19 Saturn 1 degree north of Regulus
Occultation, SAO 144070 by Juno
Full Moon
21 Mercury at greatest eastern elongation
24 Juno at opposition
26 Last Quarter Moon
29 Moon passes 0.7 degree north of Aldebaran

Mercury is visible low above the western horizon around the 21st. This is a rather unfavorable elongation, so it may be difficult to spot. Venus is not hard to spot at all; at magnitude -3.6, the planet dominates the southwestern sky at sunset. Look for it to pass within 1/10 degree of Saturn on the 10th. Mars is in the southwestern portion of the sky at sunset, considerably higher than Venus is. It sets about 2-1/2 hours after the sun. Jupiter is a lost cause; it's too close to the sun to be visible. Saturn can be seen in the western sky at sunset; it sets about two hours later. For those of you who like a challenge, Ceres and Juno will be at opposition this month. This is an opportunity to see how good your observing skills really are.



Venus, Saturn in Conjunction

On July 10, Venus passes 0.1 degree north of Saturn. The pair should present quite a contrast — Venus is bright at magnitude -3.6 when compared to the dimmer, 0.9 magnitude Saturn with its delicately structured ring system. The moment of minimum separation occurs at 8 a.m. (EDT), but North American observers will have to wait until the *evening* of the 10th to see the pair. By then, the separation will have increased about 1/2 degree.

Try viewing the pair a few days before and after the 10th as Venus zooms past Saturn. On the 8th they will be separated by 1-1/2 degrees, and on the 9th and 10th by 1/2 degree. Because the moment of minimum separation occurs at 8 a.m. (EDT), lucky observers in India and the USSR can catch it. On the North American continent, we'll have to be content with the view 12 hours after minimum separation. On the 11th the separation will increase to 1-1/2 degrees.

Above: When viewed in relation to the entire disk, sunspots don't seem that large — but they are! In the group of sunspots pictured here, the umbra (darker region) spans 72 million square miles or 1-1/5 Earth diameters. When you take into consideration the penumbra (less dark region), the span increases to 163 million miles — an area equal to two Earth diameters! This shot was taken with a Celestron 8 at prime focus, using an Olympus OM-2 camera and 1-1/3 Solar Skreen #15 filters. Kodachrome 64 film was exposed for 1/80 second. Photograph by James Felbab. Below: The Theophilus crater is featured in this shot of the lunar landscape taken with a 10 inch f/5 RFT. The exposure was 1/4 second on Fujichrome 100 film. Photograph by Ron Gattie.

Solar Eclipse '79

by

Dan Koehler

On Feb. 26, 1979, Americans and Canadians will witness the last total solar eclipse visible in North America in this century. The path of totality begins in the northwest Pacific Ocean, west of the state of Washington, at sunrise. Moving east, and later northeast, the path will move across northern Idaho, most of Montana and northwestern North Dakota. The shadow will then move into Canada, in southeastern Saskatchewan, southern Manitoba and western Ontario. From Ontario the moon's shadow will cross Hudson Bay, northern Quebec, Baffin Island, Davis Strait, and end in central Greenland at sunset.

Partial phases of the eclipse will be visible all over North America, excluding western Alaska, and Canada. The maximum amount of obscuration seen at your location during the eclipse will depend upon your distance from the path of totality. Following is a list of American and Canadian cities and the corresponding percent of eclipse:

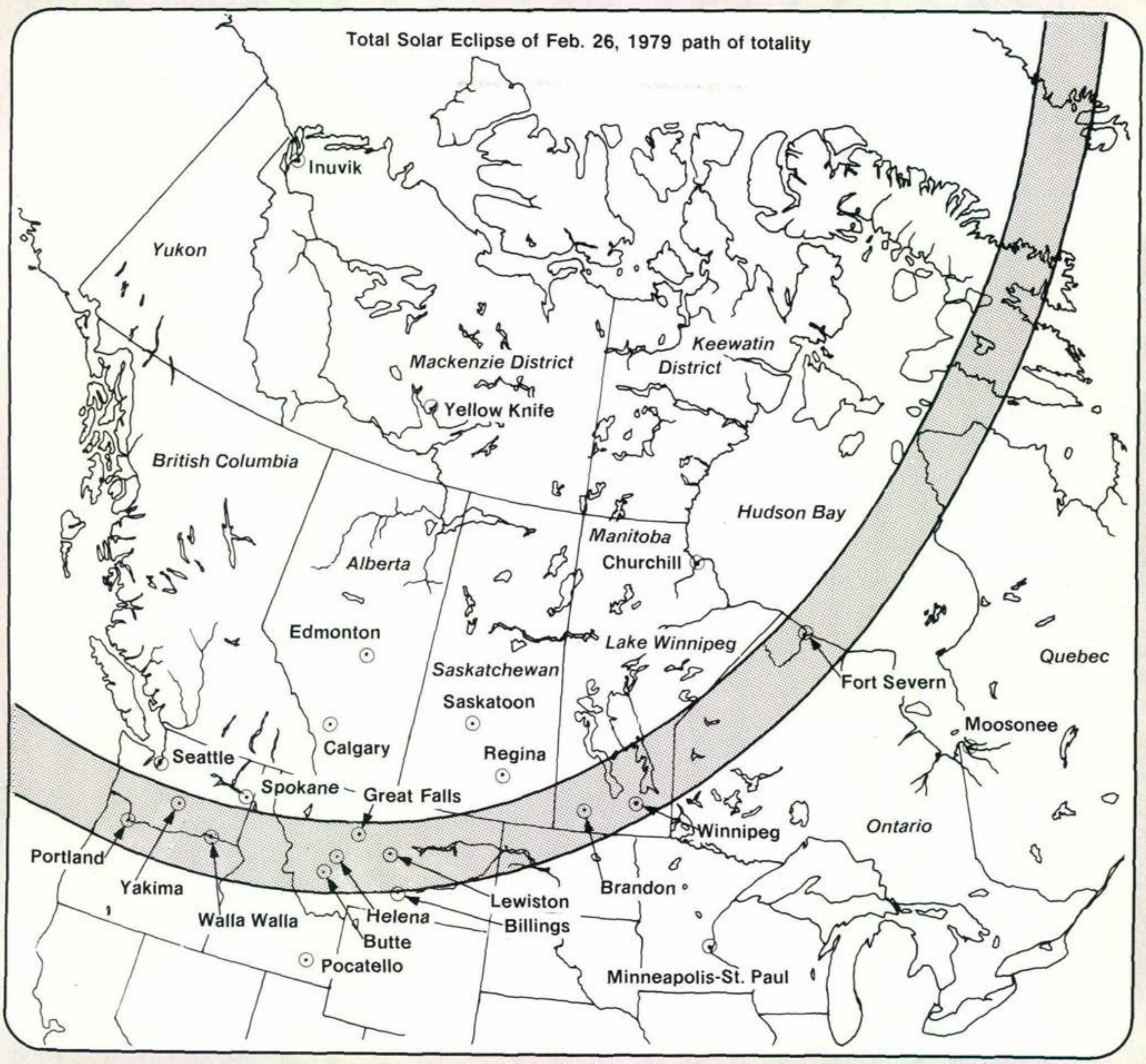
Atlanta	**56.7**	**Nashville**	**65.1**
Albuquerque	**77.8**	**New Orleans**	**53.5**
Boulder	**88.4**	**New York**	**60.8**
Chicago	**79.3**	**Omaha**	**85.4**
Cleveland	**71.9**	**Philadelphia**	**60.8**
Dallas	**66.6**	**Phoenix**	**75.3**
Denver	**87.5**	**Rapid City**	**95.4**
Detroit	**75.4**	**San Francisco**	**86.4**
Houston	**57.8**	**Washington, D.C.**	**60.2**
Indianapolis	**73.1**	**Edmonton**	**92.7**
Juneau	**85.9**	**Halifax**	**57.0**
Las Vegas	**82.5**	**London**	**74.8**
Los Angeles	**77.6**	**Montreal**	**71.4**
Miami	**31.5**	**Ottawa**	**73.8**
Milwaukee	**82.0**	**Toronto**	**74.2**
Minneapolis	**90.6**	**Vancouver**	**97.2**

Some of the locations in the United States within the path of totality and the corresponding duration times at those sites are:

(Idaho)	**Grangeville**	**2m29s**
	Kamiah	**2m30s**
	Lewiston	**2m23s**
(Montana)	**Anaconda**	**2m31s**
	Butte	**2m25s**
	Circle	**2m34s**
	Culbertson	**2m46s**
	Glasgow	**2m36s**
	Great Falls	**2m15s**
	Hamilton	**2m33s**
	Helena	**2m37s**
	Jordon	**2m40s**
	Lewistown	**2m41s**
	Missoula	**2m22s**
	Plentywood	**2m39s**
	Sidney	**2m29s**
	Utica	**2m40s**
	Winnett	**2m39s**
	Wolf Point	**2m45s**
(North Dakota)	**Bottineau**	**2m29s**
	Minot	**2m03s**
	Mohall	**2m43s**
	Rolla	**2m08s**
	Williston	**2m42s**
(Oregon)	**Astoria**	**2m11s**
	The Dalles	**2m18s**
	Elgin	**2m19s**
	LaGrande	**2m09s**
	Pendleton	**2m22s**
	Portland	**2m14s**
	St. Helens	**2m18s**
	Salem	**1m35s**
(Washington)	**Kelso**	**2m14s**
	Pasco	**2m20s**
	Pullman	**2m05s**
	Richland	**2m19s**
	Walla Walla	**2m26s**
	Yakima	**1m58s**

Locations in Canada favored for total eclipse are:

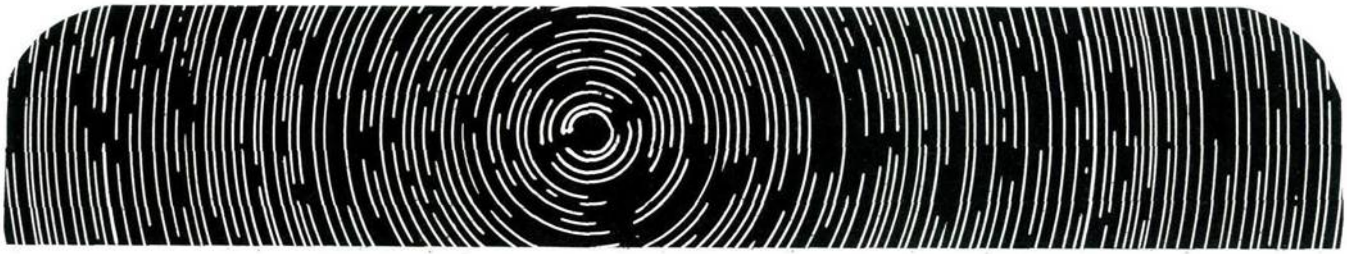
(Manitoba)	**Bisset**	**2m33s**


Total Solar Eclipse of Feb. 26, 1979 path of totality
Inuvik
Yukon
Mackenzie District
Keewatin District
Yellow Knife
British Columbia
Hudson Bay
Manitoba
Churchill
Alberta
Edmonton
Lake Winnipeg
Saskatchewan
Saskatoon
Quebec
Fort Severn
Moosonee
Calgary
Regina
Seattle
Spokane
Great Falls
Winnipeg
Ontario
Portland
Yakima
Walla Walla
Helena
Butte
Lewiston
Billings
Brandon
Pocatello
Minneapolis-St. Paul

Brandon	2m51s		**Souris**	2m51s
Delta Beach	2m50s		**Victoria Beach**	2m47s
Grand Beach	2m43s		**Winnipeg**	2m16s
Killarney	2m34s		**Winnipeg Beach**	2m46s
McCreary	2m30s	(Ontario)	**Red Lake**	1m24s
Ninette	2m43s		**Winisk**	1m47s
Portage la Prairie	2m45s	(Saskatchewan)	**Estevan**	2m43s
St. Claude	2m32s		**Stoughton**	2m18s
Selkirk	2m28s		**Weyburn**	1m55s

The maximum duration of the eclipse, $2^{m}\,52^{s}$, will occur immediately east of Lake Winnipeg in Manitoba. The maximum width of the path of totality will be 195 miles, and will be located just south of the U.S.-Canadian border near Williston, N.D. The largest city in the path of totality is Winnipeg, with a population of more than 572,000. Additional information may be obtained by requesting circular no. 157 from the U.S. Naval Observatory, Washington, D.C. 20390 (it's free for the writing).

ASTRONOMY will carry further coverage of the eclipse in an upcoming issue. Included will be maps of the most favorable locations to observe the total eclipse, climate information for locations within the path of totality, and astronomical organizations planning expeditions to the area of totality, along with more complete partial and total phase data.



GAZER'S GAZETTE

Naked Eye Astronomy, Part 1

by

Robert Burnham

If you're like most astronomy enthusiasts, you'll seldom (if ever) set out for an observing session without some type of optical aid — whether it be binoculars, telescope, camera or whatever. Why not try an observing session using only your eyes? While this may seem a little odd, if you try it, you'll find that your enjoyment of astronomy will increase and your perceptions of the sky will be heightened.

Don't forget that for all but the last 370 or so years, mankind had only his eyes to use as astronomical instruments. We have learned a great deal about the sky since the invention of the telescope, but it was during the preceding thousands of years that the heavens made their impact on man's culture. Remember, too, that many fundamental discoveries were made by astronomers with the unaided eye, including the inclination of the ecliptic, solar and lunar eclipse cycles, the inclinations of planets' orbits, precession of the equinoxes, Earth's size, and the existence of variable stars. Ptolemaic and Copernican theories were both developed using only naked eye and simple sighting instrument observations. Even the legends and starlore that have been handed down can be useful, if only as recreation. If you dismiss it all as irrelevant superstition, you're passing up a rich legacy! In short, a thoughtful approach and two open eyes will profoundly repay you for your efforts.

The preparation for observing is no different from what you'd do for any other night's observing. All you'll need are a jacket or sweater, a star atlas, red-lensed flashlight, thermos and sandwiches, and something to comfortably sit or lie on. A beach or lawn chair is fine; so is a sleeping bag. The star atlas can be as fancy or simple as you wish — but generally the simpler, the better. Norton's **Atlas of the Heavens** (field edition) or the Edmund **Mag-5** atlas are adequate; so is the Star Dome map that appears each month in ASTRONOMY.

Try to find an observing site that's far from cities, as dark as possible. These days that can mean quite a trip — but it's worth it, for the darker the sky, the more impressive it will be. Your goal is to get as close as possible to the conditions used by your pretelescopic ancestors.

If you can, try to arrive before sunset. This will allow you enough time to set up, get comfortable and to watch uninterruptedly the simple beauty of twilight coming on. As it gets dark and your eyes adjust naturally to the falling light, the stars begin to appear.

About a half hour after sunset, the first magnitude stars and some planets will be visible. In the west Venus, Mars, Saturn and perhaps Mercury will be visible. The last two of these, though, will be difficult to spot. Mercury will be at greatest eastern elongation on July 21, but the angle its orbit makes with the horizon is so shallow for viewers in mid-northern latitudes that it will never be very far above the horizon. You might not be able to spot it in the twilight glow. Saturn is in the western portion of the constellation Leo and is drawing away, after being a prominent viewing object during the winter and spring. It too may be lost in the glow. Venus and Mars are both low in the southwest and set soon after the sun. The only other naked eye planet, Jupiter, is very close to the sun in the sky and cannot be seen. While the "planet show" may leave something to be desired, the star show won't!

At the end of *astronomical twilight* (when the sun is 18 degrees below the horizon), the sky becomes fully dark. Overhead and to the east is the most prominent object in the sky, the Milky Way. The summer months — June, July and August — are the best time to see it. Apart from the weather being far more pleasant, the star fields in the Milky Way are richer and more prominent than those of winter. On a clear dark night the summer Milky Way

As the sky darkens and the stars come out, you might catch sight of elusive Mercury (at the top of the picture) or brilliant Venus (just above the clouds) before they set. This picture was taken overlooking Wausau, Wisc. on Easter Sunday evening. Later that evening, the photographer watched an intense aurora - it surely was a good night for naked eye astronomy! Photograph by Phil Valitchka.

is one of the most breathtaking spectacles in the natural world. It's easy to see why it's been such an important part of the astronomy of different cultures.

Part of its mystery and appeal has stemmed from uncertainty as to what it is made of. As you look at it, you know it's made up of billions of stars too small and faint to be individually discerned. But try to see it as it appeared to ancient man: a broad hazy stream crossing the sky from horizon to horizon. In fact, the image of a stream or path has been nearly universal for the Milky Way in all human cultures. One interesting exception to this is the Polynesian belief that it was a giant shark!

Many ancient societies wondered what the cause might be for the dark cleft in the Milky Way that lies between the constellations Cygnus and Sagittarius. It was not clear if there were simply fewer stars. Granted, we now know that the dark rift is caused by dust. But it took many years of research to establish the fact that dust was present everywhere in the Milky Way, though its distribution is knotted and clumped. Only relatively recently has it become apparent that stars are being formed in the depths of the knots, and this has become an area of intense professional interest.

In the south is the constellation Sagittarius, easily found by its "teapot" shape. Just to the right of the teapot's spout is the direction of the center of our galaxy. This region and that in Scutum, just to the north, contains the richest fields of the Milky Way to be seen. It doesn't take much imagination at all to see the thickening here which is the central bulge of the galaxy. If you turn your head to the side and imagine a bit, you'll see that the Milky Way is like the pictures of some galaxies viewed side-on, with a dust lane along the edge.

Going up the Milky Way to the north, past Cygnus at the "top" of the rift, the stars begin to thin out. Looking in the direction of Perseus, by the northeast horizon, you can see that the stars are still fairly rich, though not nearly as much as in Scutum and Sagittarius. When you look this way you're looking into an area almost opposite the center of the galaxy. The sun's location is off-center in the galaxy, which means that there are fewer stars out there "beyond" us.

While the summer sky offers no single attention-grabbing constellation like winter's splendid Orion, there is plenty to see nevertheless. One of the more

Opposite: Near the top of this picture you can see the reddish North America nebula; slightly to the right and down is Deneb, the tail of Cygnus the swan. At right center is Lyra and within it the bright star Vega. Completing the summer triangle, to the left of the page, you can see Altair, the brightest star in Aquila. Through the picture runs the Milky Way, undoubtedly the greatest sight in summertime viewing. Photograph by Martin Anderson. Above: Though the Scorpion never rises high for temperate zone Americans, it is a magnificent sight. The ruddy glow of Antares is readily apparent. Lake Roosevelt, in Kettle Falls, Wash., lies in the foreground. Photograph by Don Carney.

recognizable and aptly named constellations is Scorpio. Located just above the horizon for viewers in midnorthern latitudes, its brightest star is Antares. Its name, meaning "rival of Ares" (taken from the Greek astronomer Claudius Ptolemy), refers to its similarity in color and brightness to the planet Mars, whose Greek name was Ares.

Proceeding northward among the constellations of the Milky Way, we find Sagittarius, with the teapot shape. This area of the Milky Way is full of clusters and nebulae. In the "steam" from the spout of the teapot is the Lagoon nebula (M-8). This gas cloud is visible to the naked eye as a round patch. Its full extent (as revealed in photographs) is near the size of the full moon. Find it by following a line from Phi and Lambda Scorpii (these are the stars on the side of the teapot by what would be the handle) up to the northwest, a distance equal to that separating the two stars. One degree above the Lagoon is the Trifid nebula, another gas cloud — but more difficult to see.

The next prominent constellation to the north along the Milky Way is Aquila. This has a first magnitude star, Altair, and several other stars of magnitude 2.6 or fainter. The most interesting of these is a Cepheid type variable star, Eta, which fluctuates between 3.7 and 4.5 magnitudes over about a seven day period. It can easily be followed by the naked eye, and after a few nights you'll notice a change. It is surrounded by a rough box of stars: Beta (magnitude 3.9), Delta (3.4), Iota (4.3) and Theta (3.4), which can be used as comparison stars. You might keep a log book, noting each night how bright Eta is compared to the others.

Altair is the southernmost point of the sky triangle, the other two points of which are Deneb in Cygnus and Vega in Lyra. This latter constellation is very distinctive, though small. Four of its stars form a parallelogram, with Vega just to the northwest. Lyra also has an easy-to-follow naked eye variable. This is Beta, the southwest corner of the parallelogram. This type of variable is different from the other two mentioned in that unlike them, its brightness changes come from without the star rather than from within. The star is really two stars in close orbit around each other, one brighter than the other. When the brighter is covered up by the dimmer, the brightness of the two (as seen from

Earth) drops. The period is about 13 days. For a comparison star, use Gamma (magnitude 3.3), the southeast corner of the parallelogram.

Just northeast of Vega is 4.5 magnitude Epsilon, the famous double double star. With the naked eye alone, you'll only be able to split Epsilon once; to split each of these two into *their* two components requires a telescope. Vega itself is a flashing diamond of the purest white. It seems to hold a special fascination as it passes almost directly overhead.

Passing directly westward from Lyra, we find Cygnus the swan, also known as the Northern Cross, which seems to be flying down the Milky Way. Later in the year as the constellation sets, it appears to stand upright on the western horizon as a large cross, which no doubt led to its alternative name. It has many variable stars, but the most prominent is Chi, which lies on the line between Gamma at the center of the cross arm and Beta (or Albireo) at the south tip of the cross. In fact, there are two stars here at the midpoint. The northerly one is Eta, which has a magnitude of 4.0 and is a good comparison star. The southerly one is Chi, a long period variable star with a range in magnitude from 4 to 14. It should be at maximum brightness in September, so it will be easily visible over the summer. When it's at minimum light, you'd need an eight inch telescope or better to spot it. The brightest star in Cygnus is Deneb, the easternmost point of the sky triangle. Just northwest of Deneb is the famous North American nebula, which appears as a patch about the size of the moon. This huge cloud of hydrogen gas glows from the fierce light of several hot stars within it.

Between Cygnus and the W-shaped constellation Cassiopeia lies the somewhat unobtrusive Cepheus. While this constellation offers little to the naked eye observer, it contains one star that is important. This is Delta Cephei, the founding member of the Cepheid class of variables. These variables were the first ones to be used as distance indicators, and it is no exaggeration to say that they have allowed the scale of the universe to be computed. At the eastern corner of the constellation is a small triangle made up of three stars; Delta is the one that is closest to Cassiopeia. It ranges from magnitude 3.7 to 4.3 over about 5-1/2 days. The other two stars, Zeta on the north and Epsilon on the south, are 3.6 and 4.2 magnitudes respectively. These make easy comparison stars for following the changes in Delta.

Over to the northeast in Andromeda you can see the most distant object visible to the naked eye: M-31, the great galaxy. The light from this oval patch of haze has been traveling for over two million years! It has been likened to a candle shining behind a sheet of thin horn in appearance, and its importance to astronomers comes from many things — not the least of which is that it resembles what we think our galaxy would look like from outside.

There are many activities you can do with a sky like this: Try to trace out as many different constellations as you can find with the atlas. Believe it or not, this can be hard on a very clear night as there are so many stars that the familiar bright ones get lost in the throng. Or you can try inventing your own constellations and groupings. The 88 that now exist are fixed by international agreement, but there is no reason why you can't honor your friends and yourself with a place in the heavens.

If you gaze at the sky for any time at all, you'll certainly see a number of meteors, or shooting stars. These come in two kinds: groups or streams (showers), providing regular shows at set times throughout the year, and those that appear randomly. Of the random or sporadic ones, you should see one every few minutes somewhere in the sky. The grouped ones arrive at specific intervals during the year, with the best show being the Perseids (named after the constellation from which they appear to come) in the first half of August. A careful lookout (especially in the morning hours) from mid-July on should show increasing numbers of them until they taper off in mid to late August. The show can be easily wiped out by moonlight which brightens the sky so much that they are lost. This year's show has the moon between new and first quarter, so it should be relatively unaffected by the moonlight.

If there has been any solar flare activity lately you might see an aurora. The sun is now at a relatively inactive part of its 11 year cycle, but activity is increasing rapidly. Look to the north for a glow that cannot be caused by a city or cloud. The aurora is caused by high speed particles from the sun becoming caught by Earth's magnetic field. They swirl down and strike the gases in the upper atmosphere, making the glow. The color is usually gray-green or green, but occasionally higher energies will push the color to red.

As you become more and more familiar with the sky, you'll find that you have almost memorized the stars. This will help you spot anything that "isn't right". Many novae (stars that flare up greatly in brightness in an unpredictable manner) have been discovered this way. You'll also be surprised by how soon you learn to spot even dim and slowly moving satellites.

If you have stayed out the whole night, just before dawn you'll see the Pleiades rising in the east, followed by Aldebaran and the Hyades. The Big Dipper will be low in the north and Great Square of Pegasus on the meridian in the south. The summer stars will be setting and the winter ones rising — a signal that it's time to go to bed.

Top: Even hazy evenings can afford great visual pleasures, such as this fine halo surrounding the moon and Jupiter in November 1976. Photograph by Stephen Berr. Bottom: Can you split Epsilon Lyrae's wide components by eye? Epsilon is almost directly above the bright star Vega in this view over alpine firs in Washington's Kettle Mountains. Photograph by Don Carney.

Meade precision 6" and 8" reflecting telescope systems give you full photo-visual capabilities.

Meade 6" and 8" reflectors achieve a new level of optical and mechanical excellence for the serious amateur. These totally integrated telescope systems include everything required for detailed study of the Solar System and Deep Space, and readily permit the observer to grow into more advanced subjects, such as long-exposure astrophotography. Designed by Meade engineers and manufactured at our Costa Mesa facility, these telescopes possess capabilities generally obtainable only at much higher prices—and they are the only telescopes available which use exclusively the quality Meade components known throughout the astronomical world.

Research-Grade Optics: Meade paraboloidal primary mirrors and elliptical secondary mirrors are of fine-annealed Pyrex, ground and polished to 1/10-wave surface accuracies. There are no finer optical systems obtainable.

Precision-Machined Equatorial Mounts: Each mount includes a ball bearing at the critical thrust point of the Polar Axis, and will easily accept the weight of heavy cameras, guide telescopes, and auxiliary systems. Mount components are individually machined at our factory to tolerances within .001". Setting circles are provided on both axes for the location of faint objects.

Accurate Electric Drive Systems (115v/60Hz): Utilize clutch and gear components designed to satisfy rigid astrophotographic requirements. Models which include the Meade motor drive system also incorporate a manual override control in R.A. for precise centering of the object in the telescopic field. For foreign operation, 220v/50Hz drives are available.

Full Photographic Capability: All instruments include prepositioned focal point settings for both eyepiece-projection and first (prime) focus astrophotography.

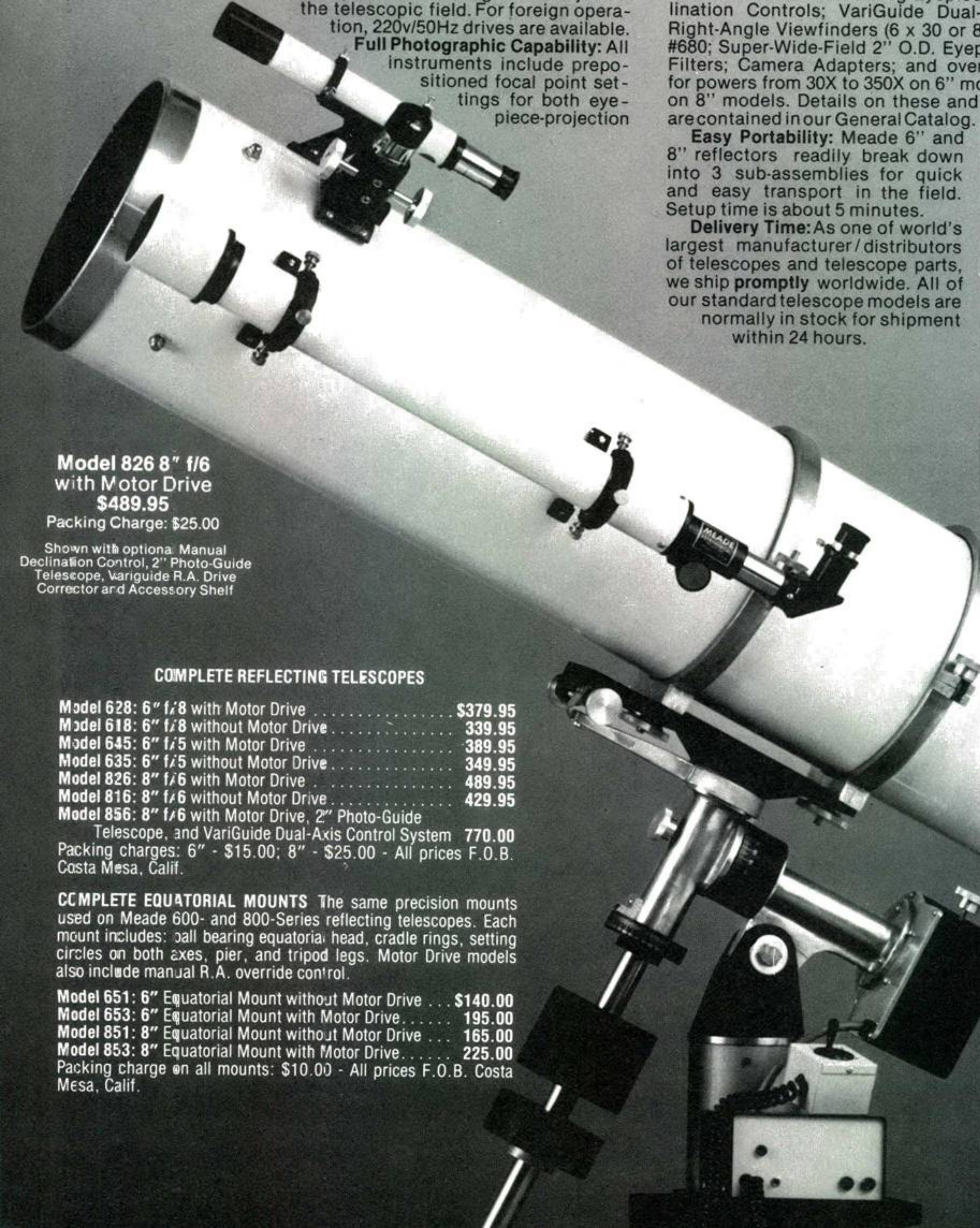
Quality Components and Accessories: Standard equipment on all 6" and 8" Meade reflectors — 6 x 30mm achromatic viewfinder with crosshair eyepiece; precision #67 rack and pinion focuser accepting 1¼" O.D. eyepieces; gleaming white Fiberlite tube, fully rotatable, with polished metal end rings; 4-vane spider; and 2 achromatic coated Kellner eyepieces; 9mm (135X) and 25mm (49X).

Optional Systems and Accessories: Buy a telescope which will expand to fill your future requirements. Meade optional accessories permit the widest possible opportunity for advanced applications, and each accessory, as part of an integrated system, attaches easily and accurately to any Meade reflector. Optional accessories which may be ordered either with the telescope or at a later date include: 2" Photo-Guide Telescope; Illuminated Reticle Guiding Eyepiece; Manual or Electric Declination Controls; VariGuide Dual-Axis Corrector Systems; Right-Angle Viewfinders (6 x 30 or 8 x 50); Deluxe 2" Focuser #680; Super-Wide-Field 2" O.D. Eyepieces; Photo-Visual Color Filters; Camera Adapters; and over 20 additional eyepieces for powers from 30X to 350X on 6" models and from 30X to 550X on 8" models. Details on these and other Meade accessories are contained in our General Catalog.

Easy Portability: Meade 6" and 8" reflectors readily break down into 3 sub-assemblies for quick and easy transport in the field. Setup time is about 5 minutes.

Delivery Time: As one of world's largest manufacturer/distributors of telescopes and telescope parts, we ship **promptly** worldwide. All of our standard telescope models are normally in stock for shipment within 24 hours.

Model 628 6" f/8
with Motor Drive
$379.95
Packing Charge: $15.00
Shown with optional camera adapter



Model 826 8" f/6
with Motor Drive
$489.95
Packing Charge: $25.00

Shown with optional Manual Declination Control, 2" Photo-Guide Telescope, Variguide R.A. Drive Corrector and Accessory Shelf

COMPLETE REFLECTING TELESCOPES

Model 628: 6" f/8 with Motor Drive	**$379.95**
Model 618: 6" f/8 without Motor Drive	**339.95**
Model 645: 6" f/5 with Motor Drive	**389.95**
Model 635: 6" f/5 without Motor Drive	**349.95**
Model 826: 8" f/6 with Motor Drive	**489.95**
Model 816: 8" f/6 without Motor Drive	**429.95**
Model 856: 8" f/6 with Motor Drive, 2" Photo-Guide Telescope, and VariGuide Dual-Axis Control System	**770.00**

Packing charges: 6" - $15.00; 8" - $25.00 - All prices F.O.B. Costa Mesa, Calif.

COMPLETE EQUATORIAL MOUNTS The same precision mounts used on Meade 600- and 800-Series reflecting telescopes. Each mount includes: ball bearing equatorial head, cradle rings, setting circles on both axes, pier, and tripod legs. Motor Drive models also include manual R.A. override control.

Model 651: 6" Equatorial Mount without Motor Drive	**$140.00**
Model 653: 6" Equatorial Mount with Motor Drive	**195.00**
Model 851: 8" Equatorial Mount without Motor Drive	**165.00**
Model 853: 8" Equatorial Mount with Motor Drive	**225.00**

Packing charge on all mounts: $10.00 - All prices F.O.B. Costa Mesa, Calif.

Research level telescope parts and accessories from America's No. 1 supplier to the serious amateur

1 - Series 1 KELLNER EYEPIECES (1¼″ O.D.) — Highly corrected, 3-element design, fully coated. The best in moderately-priced eyepieces. Barrels threaded for our filters. **Focal lengths: 6, 9, 12, 25mm . . . each $14.50 ppd. — 40mm Wide-Field . . . $16.50 ppd.**

2 - KELLNER 40mm EXTRA-WIDE-FIELD EYEPIECE (1¼″ O.D.) — Yields widest field obtainable in 1¼″ O.D. Enlarged field lens and special field-flattening optics with long eye relief. Barrel accepts our filters. **$24.75 ppd.**

3 - Series 1 ORTHOSCOPIC EYEPIECES (1¼″ or .965″ O.D.) — Our most popular eyepieces, over 25,000 now in use. Classical 4-element design, 45° field, fully coated, with precise corrections for color and field flatness. All 1¼″ barrels are threaded for our filters. **Focal lengths: 4, 6, 9, 12.5, 18, 25mm . . . each $23.75 ppd.**

4 - Research-Grade ORTHOSCOPIC EYEPIECES with Multi-Coated, Parfocal Optics (1¼″ O.D.) — The largest-selling premium-quality eyepieces in the world, universally acclaimed to be the finest oculars obtainable. These 4-element systems are unsurpassed in resolution, color correction, and flatness of field. Air-to-glass surfaces are 7-layer multi-coated for maximum image contrast and light transmission. 45° field. Precisely parfocal. Barrels threaded for our filters.

Focal lengths: 4, 7, 10.5, 16.8, 28mm . . . . each $38.95 ppd.
Set of any 4 Research-Grade Orthoscopics . . . . 151.00 ppd.
Set of any 4 plus Res. Grade Erfle 20mm. . . . . 193.00 ppd.
Full set of 5 Research-Grade Orthoscopics plus Erfle 20mm . . . . 229.50 ppd.
(Sets of 4, 5, or 6 eyepieces are shipped in fitted carrying case — see #25 — at no additional charge.)

5 - Research-Grade ERFLE 20mm (1¼″ O.D.) — Parfocalized with our Research-Grade Orthoscopics and 7-layer multi-coated. 75° apparent field for breathtaking wide-angle observations. Barrel accepts our filters. **$44.50 ppd.**

6 - Zoom Kellner Eyepiece (.965″ O.D.) — Fine 4-element design. Zoom range 7.5mm - 22.5mm. Fully coated optics . . . **$32.95 ppd.**

7 - Zoom Orthoscopic Eyepiece (1¼″ O.D.) — Zooms instantly from 8.4mm to 21mm, with excellent image corrections at all powers. Wide 50° field at 8.4mm. Fully coated optics. **$49.95 ppd** - Filter adapter #004: couples our filters to above eyepiece . . . **$1.00 ppd.**

8 - Photo-Visual Color Filters - Top quality optical glass, dyed-in-the-mass, with excellent spectral homogeneity. Mounted in machined metal cells which thread directly into all our 1¼″ "Series 1" and "Research-Grade" eyepieces. Filters may be piggybacked. Listed by Wratten No. and color: **#8 Light Yellow - #11 Yellow-Green - #12 Yellow - #21 Orange - #23A Light Red - #25A Red - #47 Violet - #58 Green - #80A Medium Blue - Polarizer (30% transmission).** Each filter: **$6.95 ppd.** Set of any 6: **$39.50 ppd.** - Full set of 10: **$64.50 ppd.**

9 - VariPak Drive Corrector — This low-cost quality unit includes all the features required for the majority of guiding applications. New super-compact (2″ x 3″ x 4″) design, with fast-slow pushbuttons mounted on the power pack. Variable control for lunar, planetary, sidereal rates. Operates from 12 volts D.C. The 8 watt output is sufficient for most telescopes to 10″ aperture. **$59.95 ppd.**

10 - VariGuide Drive Correctors — The finest R.A. drive correctors available. Each unit includes aircraft-type joystick controller for continuously variable correction rates, not just "ON-OFF". Models 40 and 41 may be used with any motor-drive-equipped telescope rated up to 10 watts, including most commercial telescopes to 12½″ aperture.
Model 40 — Operates from 12 volts D.C. Control box includes variable center-frequency settings for lunar, planetary, sidereal rates. **$89.95 ppd.**
Model 41 — Identical to Model 40, but operates from either 12 volts D.C. or 115 volts A.C./60Hz. **$119.95 ppd.**

11 - VariGuide Dual-Axis Corrector Systems — For the advanced astrophotographer. Universal joystick controllers permit continuously variable correction rates **simultaneously** on **both** telescope axes. Each unit includes electronic control systems for both R.A. and Declination, along with all required mounting hardware. Models are available to fit Meade 600- and 800-Series reflectors and for the Celestron 5 and 8, as noted. After 15 minutes' installation, you will be using the most sophisticated and precise guiding system ever offered the serious amateur.
Model 47M — Attaches to Meade 600- and 800-Series reflectors. Operates from either 12 volts D.C. or 115 volts A.C./60Hz. **$215.00 ppd.**
Model 47C — Attaches directly to Celestron 5″ and 8″ telescopes. Operates from either 12 volts D.C. or 115 volts A.C./60Hz. **$195.00 ppd.**

RACK-AND-PINION FOCUSERS — Precision metal construction. All 3 models include helical-cut rack and variable-tension adjustment for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1¼″ eyepiece holders. **Each focuser is guaranteed to be the finest obtainable in its class.**

12 - Model #67 — Strong, lightweight design for 4″ to 10″ telescopes. 2-3/16″ travel. An excellent value. **$19.75 ppd.**

13 - Model 640 — A heavy-duty deluxe focuser for 6″ to 16″ telescopes. Full 3″ travel for both visual and photographic applications. **$33.95 ppd.**

14 - Model 680 — Our finest focuser. Accepts both 1¼″ and 2″ eyepieces. Full 3″ travel for photo or visual observing with 6″ to 16″ telescopes. **$39.95 ppd.**

15 - Deluxe Camera Adapters — Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum. All units permit both eyepiece-projection and first (prime) focus photography. Specify either .965″ or 1¼″ focuser. All 1¼″ units are threaded for our filters. Pentax, Yashica, Mamiya . . . **$18.95 ppd.** - Nikon, Canon, Minolta, Pentax K, Exakta, Konica . . . **$27.95 ppd.** - Olympus OM-1, OM-2 . . . **$28.95 ppd.**

16 - 2″ First (Prime) Focus Adapter — For use with #680 Focuser or equivalent. Yields widest photographic field obtainable with 35mm cameras. For any of the above-listed camera brands (specify brand) . . . **$27.50 ppd.**

VIEWFINDERS — Each finder includes coated, achromatic objective lens and crosshair eyepiece.

17 - 6 x 30mm — Fine, 4° wide-field finder. Thousands now in use. 2-ring bracket included, fits all tubes 6″ to 12½″. **$21.95 ppd.**

18 - 6 x 30mm Right-Angle — As in (17), but with diagonal prism for convenient right-angle observations. Bracket included. **$27.95 ppd.**

19 - 8 x 50mm — 5° field and large 50mm aperture. Sharp, brilliant images. **$33.95 ppd.** Brackets: **$7.95/pr. ppd.**

20 - 8 x 50mm Right-Angle — As in (19), but with diagonal prism. For both straight-through and right-angle viewing. **$39.95 ppd.** Brackets: **$7.95/pr. ppd.**

2″ O.D. SUPER-WIDE-FIELD EYEPIECES — Premium-quality wide-field eyepieces for 2″ focusers. The ultimate in rich-field performance. Fully coated.

21 - ERFLE 32mm (2″ O.D.) — Sophisticated 5-element optical system. Wide, flat 65° field . . . **$94.50 ppd.**
ERFLE 32mm (1¼″ O.D.) — As above, but 1¼″ O.D., 60° field . . . **$94.50 ppd.**

22 - KELLNER 60mm (2″ O.D.) — Low power, long eye relief. Ideal for deep-space observations . . . **$49.50 ppd.**

23 — 2X and 3X TELENEGATIVE AMPLIFIERS (1¼″ O.D.) — Warranted, without qualification, to be the world's finest Barlow lenses. Full 26mm clear aperture, with virtually flawless optical corrections at all photo-visual wavelengths. Produces optimum performance on telescopes of any focal ratio. Fully coated. **2X Model 122 . . . $29.50 ppd. - 3X Model 123 . . . $32.50 ppd. - Combination 2X and 3X Model 124 . . . $39.50 ppd.**

24 - Fiberlite telescope tubes, mirror cells, spiders, primary mirrors from 6″ to 12½″ diameter, secondary mirrors, and objective lenses are available for immediate shipment. (Phone, or request catalog, for details.)

ACCESSORY CASES — Rugged polyethylene, for dust-free protection of eyepieces, filters, Barlows, etc. Die-cut foam lining.

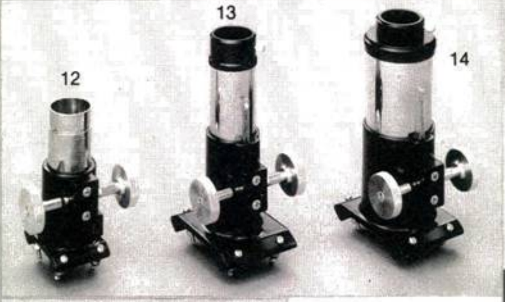
25 - Model #51 — 7″ x 8½″ . . . $8.95 ppd.

26 - Model #54 — 8″ x 12″ . . . $12.95 ppd.

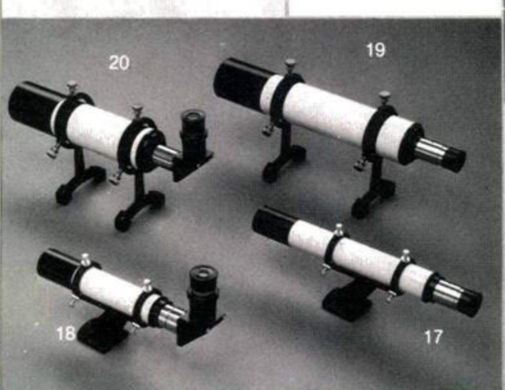
27 - ILLUMINATED RETICLE GUIDING EYEPIECE (1¼″ or .965″ O.D.) — For professional-level photographic guiding. Kellner 12mm optical system, with precisely focusable 4-line glass reticle. Remote brightness control and 3 ft. cable. (Extension cables available.) Complete . . . **$44.95 ppd.**
Micrometer Reticle: Full-field scale for accurate measurements of double star separations, planetary angular diameters, etc. Interchanges with standard 4-line reticle . . . **$14.95 ppd.**

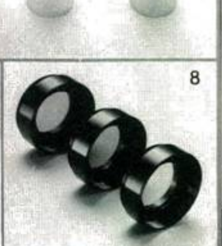
28 - ERECTING PRISMS — Fully coated Porro prisms, for terrestrial observations with astronomical telescopes. **1¼″ O.D. . . . . . . $29.95 ppd. — .965″ O.D. . . . $19.95 ppd.**

29 - DIAGONAL PRISMS — Quality right-angle prisms, fully coated. **1¼″ O.D. . . . $19.95 ppd. — $.965″ O.D. . . . $14.95 ppd.**



Meade



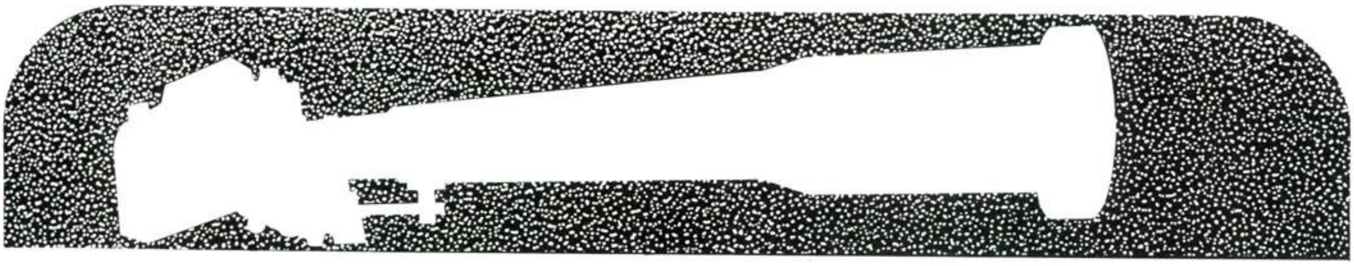


Mail Orders: Write us your requirements — or use the order form which accompanies our catalog.
Telephone Orders: Accepted with payment either C.O.D. or credit card (we do not accept collect calls).
Payment: Personal or bank check, money order, or credit card (BankAmericard/VISA or Master Charge).
Shipment: All orders are processed for shipment within 24 hours.
California Residents: Add 6% Sales Tax. Canadian Orders: Add 10% to cover priority mail charges.
Foreign Orders:(Outside North America): Add 20% to cover Air Parcel Post charges — any excess will be refunded. Payment must be made by bank check in US $.
General Catalog 78-C —$1.00 (Outside North America $2.00 for Air Mail). (Catalog free with any order.)

Card No. ______________________________ Expiration Date ___/___/___
Name ______________________________
Address ______________________________
City ____________________ State ____________ Zip ____________

Meade Instruments Corporation 721 W. 16th Street, Costa Mesa, Calif. 92627 **(714) 646-9281**

© 1978 Meade Instruments Corp. TM Series 1, Research-Grade, Fiberlite, VariGuide, and VariPak are trademarks of Meade Instruments Corp.



Astrophotography–With Camera Only!

by

Richard Berry

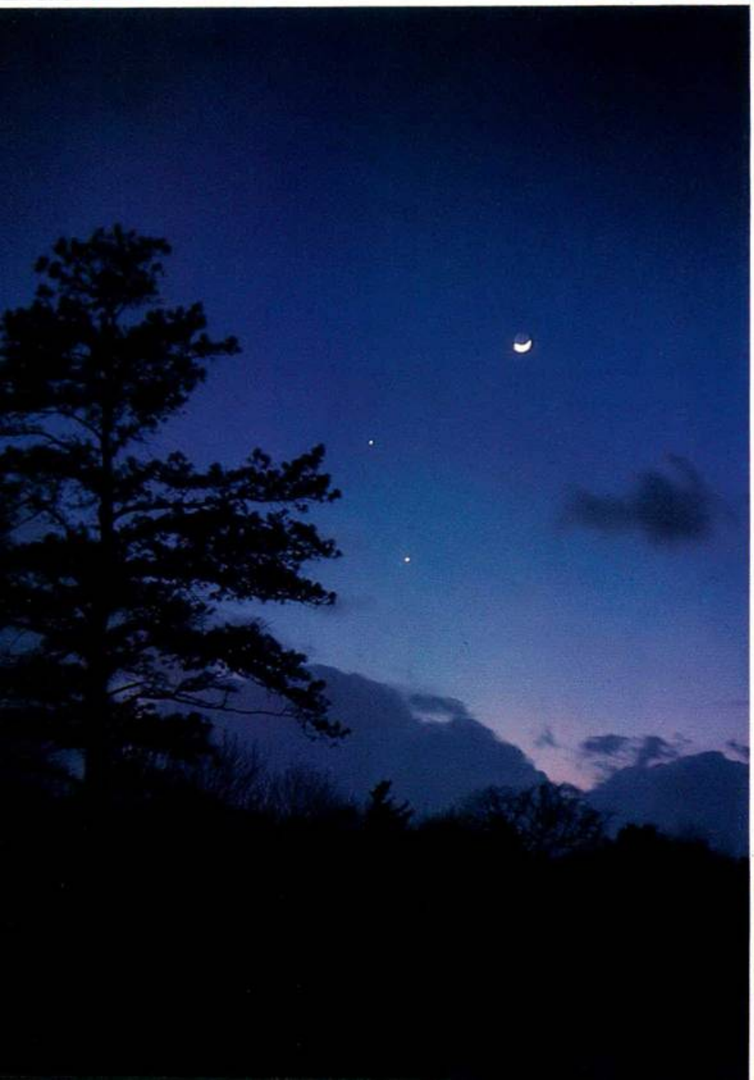
Do you dream of astrophotography . . . but don't have a telescope? Do you read and hear about fancy gadgets, expensive doodads, spectrowhatsit films, long, long exposures, and then heave a sigh? You shouldn't, because the pictures in these pages show that a perfectly ordinary camera — with no extra gadgetry fancier than a tripod to support it — can yield results to be proud of!

Before going any further, let's talk critically about astrophotography for a moment. Why, you may reasonably ask, would anybody want to take pictures of things in the sky? Why not just *look* at the stars to enjoy them, and have some pleasant memories rather than tacky little prints from the corner drugstore? Actually, you ought to just look — quite a bit: Nothing else really beats visual observing. After all, fussing around with gadgetry does take much of the fun away from looking, but as you do become more familiar with the sky — after you've learned the constellations — you may want to share your experience with others, and you may want to see some of your friendly stars as only a camera sees them.

A camera doesn't "see" the same way people do. Human eyes hold an image only for a fraction of a second before it fades and a new picture forms. You can see motion where a camera will only record a blur. The camera image *accumulates*, continuously building up as long as the shutter is open. If something in the picture moves, it's recorded in more than one spot, or as a blur. Because the image accumulates, if you leave the shutter open for a long time, you'll eventually record things that are dimmer than your eyes can see. Vision goes on to form a new picture, while the camera eye just goes on adding to the same one. Your camera can compress time for you, letting you see the slow trailing of stars in a single glance. The camera will record star colors too dim to see by eye, because it accumulates light. A photograph is permanent too — at least more permanent than memory — and pictures can revive your memory of the beautiful starry night you took them. The camera doesn't see "better" — it only sees "differently".

To do astrophotography, first and foremost you must own a camera. Virtually any camera will do, though 35mm cameras have an edge over Instamatics and box cameras because they usually have adjustable lenses and can make time exposures. One of the deepest, darkest, most closely guarded and fought-over secrets of cameradom's Madison Ave. types is that all (or virtually all) 35mm cameras will make just about the same picture — and the quality of the image is only slightly correlated with the price. Picture quality really depends on the photographer; the sales pitch is based on frills. More expensive cameras, admittedly, are better built,

Top: The camera records by adding and adding to a single image. As our Earth turned, carrying with it the trees and camera, the stars remained fixed. But images of the stars slowly moved across the film in this half hour exposure. Photograph by Mike Barr. Bottom left: A simple five second exposure at f/1.8 on Kodachrome 64 sufficed to record this grouping of Venus, Jupiter and the crescent moon in February 1975. Four nights later, after the moon had moved on, Venus passed close to Jupiter in a spectacular conjunction. Photograph by Stephen LaBarre. Bottom right: With your camera's lens wide open and fast film in the camera, you can't miss the constellations. Fifteen seconds captured both Orion and a row of winter trees. Photograph by Diane Payton.



Opposite top: Being in the right place at the right time is often a matter of planning. Anticipating the appearance of Venus over the pond in morning twilight was essential in making this picture. The exposure was four seconds on Kodachrome 64 at f/2 with a 50mm lens. Photograph by Fred Espenak. Lower left: On the morning of Aug. 11, 1977, the moon (here drastically overexposed) helped form a striking group with Venus, Jupiter and Mars. This scene was recorded on GAF 500 film, home processed to an effective ASA of 2000, accounting for the unusual appearance. Photograph by Karl Simmons. Lower right: Shining in the sky, this cloud of gaseous barium was released moments earlier from a research rocket. A 15 second exposure at f/1.4 on fast film recorded the event. Photograph by Tom Fleming. Above: With solar activity on the rise, northern observers will see more aurorae. Using a 20 second exposure at f/1.8, this beautiful drapery aurora of Jan. 30, 1978 was captured on Ektachrome 200, and push processed to ASA 400. Photograph by Don Carney.

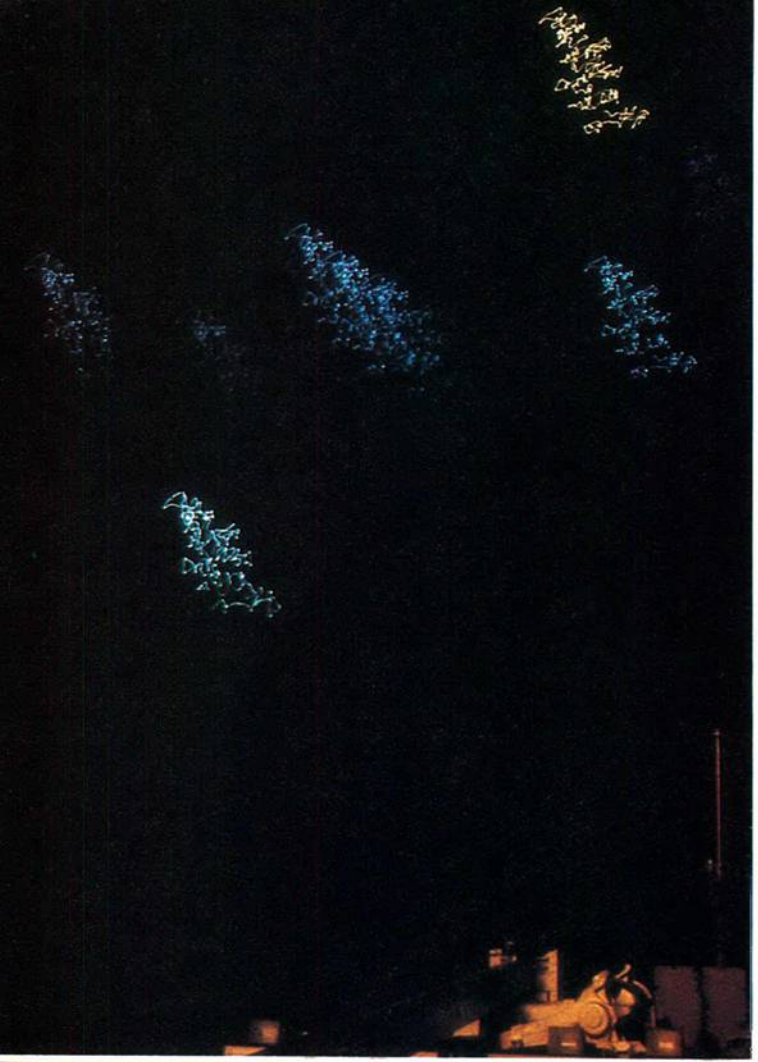
and might take 20,000 rolls of film before they wear out, while a much less expensive camera might wear out in 2,000 (five years worth of picture taking at a roll a day!). If you're buying your first camera, you needn't buy an expensive camera unless you want a lot of "features" you probably won't use anyhow.

What do you *need?* Obviously a camera — preferably a single lens reflex type with a lens faster (having a smaller f/number) than f/3.5, and the ability to make time exposures. And, yes . . . a sturdy tripod.

One requirement is the camera; the other is the film. You'll have a choice of black and white prints, color prints, or color slides. Generally, the most beautiful and impressive route is via color slides. Common commercial black and white prints are lackluster; commercial color prints are too small. Without trying to make a case for doing your own darkroom work, it's simply true that if you want astrophotographic printing done well, you have to do it yourself.

Slides are much simpler. There's nothing to go wrong — the slide is the finished product. Slide projectors enable you to make instant blowups of your transparencies to 30, 60, even 100 times enlargement directly on a white wall, big sheet of paper or projection screen. Although you can't just hand slides around to your friends, you can have color prints made from slides at almost any photo store (or you can do it yourself if you have a darkroom setup). Since you won't need prints of every picture on the roll either, you can have bigger prints made of just a few good subjects.

What film should you use? Among slide films, Kodak's Ektachrome 200 is the choice if you're addicted to yellow boxes; Fujichrome R-100 also enjoys a good reputation. GAF 200 and GAF 500, General Analine and Film's high speed color materials, have been discontinued. "Push" processing, available through Kodak, can take the speed of Ektachrome 200 up to ASA 400 while retaining good image quality. In each of these films, the important characteristic is speed, or the film's sensitivity to light. The higher the film's "ASA" rating, the more



sensitive it is. For astrophotography, an ASA of at least 100 is desirable.

You may want to use print film despite the advantages of slide films; after all, your priorities are what count. A number of excellent ASA 400 films have become available in the last six months or so, and any of them will produce good prints. If you want to take black and white pictures, the old standby (Kodak's Tri-X) and its rival (Ilford HP-5) will serve most beginning astrophotographers well. Both are ASA 400 and both produce a much sharper, crisper image than the ASA 400 color films.

Equipped with a camera and film, what should you shoot? If you just want to take pictures for the purpose of taking pictures, the answer is probably "nothing". Let what's happening in the sky (or rather your interest in it) dictate what you photograph. If constellations fascinate you, then — by all means — that's what you'll want to photograph. If you're intrigued by the gyrations of a planet coming to opposition, perhaps you'll want to take a series of pictures a few weeks apart showing, as you might have, this year's apparition of Mars. Does the motion, the rising and setting of stars or the spin of stars about the pole interest you? These are *your* subjects and *your* pictures; if you aren't interested, intrigued, fascinated, dumbfounded, curious or appreciative, you won't enjoy making the pictures or looking at them after they come back from the photofinisher.

Once you're interested in something, there isn't much to getting the picture. Attach your camera firmly to the tripod, set the shutter for a time exposure, focus the lens for infinity, and frame your subject (or subjects) in the viewfinder. The size of the camera's field is a limitation — it'll cramp your style until you get to know just how much sky it covers. Once you're used to it, it won't really bother you.

The aperture (f/stop) of your camera is probably between f/3.5 and f/1.2 — and most likely f/1.8, f/1.9 or f/2 (which are just about the same). For any of these apertures, a good trial exposure is 10 seconds. Push the shutter button, count off "one-lollipop, two-lollipop, three-lollipop . . ." and so on, up to 10. In a 10 second exposure, stars will not move noticeably, and you'll probably find several dozen on your slide. Since conditions vary from place to place, you'll want to try some other exposures too. Try doubling the basic 10 seconds, then doubling again, and again. The 80 second exposure will show definite star trailing and (if you live in the city) may be overexposed too. Just for the sake of finding out what you'll get, try halving the exposure several times also: Try five, then two, then one second. You can do these trials on the end of an old roll of vacation pictures, the family dog and a day at the beach — it requires at least seven frames.

Top left: You needn't feel obliged to take the same kind of star trails everybody else does. From the deck of the cruise ship Daphne, sailing in the Caribbean, this 20 minute exposure records the ship's roll as well as star trailing. In the foreground are cranes and the ship's superstructure. Photograph by Kevin Parker. Top right: This fine grouping of Venus, Saturn, Castor and Pollux occurred on the evening of May 17, 1975. The trees, in new leaf at the time, add to the beauty of the picture. Photograph by Diane Payton. Bottom: The same event looks very different as a prolonged set of star trails. This 75 minute exposure, followed by a 45 second wait, then a five second exposure, produced the untrailed images at the start of the trails. Photograph by Norman Happe.

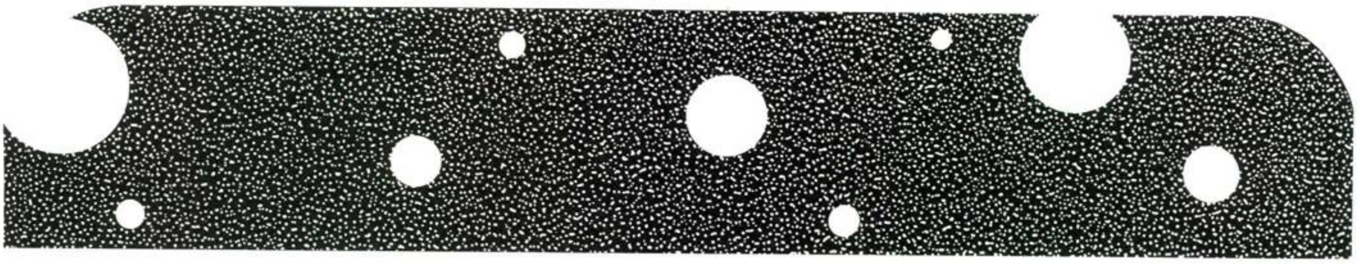
After they come back, examine the frames carefully. Notice just how many stars and how much trailing each one shows. Then see whether any background sky light has recorded, or whether you only got black. (If you put a tree or house silhouette at one side when you take the pictures, it'll be easier to tell this.) One of the frames will be most pleasing to you — it might show the most stars with the least trailing (if you're trying to get a constellation), or it might show Mars and just a few other stars (if that's what you're trying to record).

Your second roll can be shot with some security; you'll know approximately what you're going to get. Try some experiments, though. If your 80 second exposure was not too light, double it again, and again and again. If it was too light, set the aperture to f/5.6; then try 160, 320 and 640 second exposures. The stars will really trail then, though the small lens opening won't record as many as the bigger lens opening. You may want to continue with exposures running into many hours if you're out in darker country skies: Arcs of stars will cut across the full width of the frame, or circle the pole magnificently.

Do you want to watch a moonrise? Set the camera aperture to f/11 or f/16. Begin your exposure shortly before the moon comes up, and continue it an hour or two after it has risen. The moon will streak across the frame. Do you want a time lapse effect? Set the aperture for f/5.6; then open the shutter with the lens cap *on.* Every five minutes remove it for a second, and then replace it. Each moon image will add to the previous ones, like a sequence of beads on a string.

Does Venus shine in a picturesque manner over a railway yard you pass every evening? No problem: the basic 10 second exposure is probably about right, but try a few shorter exposures too if there's any twilight glow left. Red sunset glow and the deep blue-purple of the sky compliment this brilliant planet nicely. It's really a matter of looking and seeing — the picture comes afterward.

Doing is the best way to learn. Sure you're bound to come up with lots of "spoiled" frames, but each one is a lesson in how the film and camera translate the scene before you into specks on a slide or print. Look at them, study them . . . then try again, this time knowing a bit more. Soon you'll be able to answer the question: "Why would anybody want to take pictures of things in the sky?"



Gravity, Dust and Solar Neutrinos

by

John Gribbin

The absence of any detectable flux of neutrinos from the sun has produced a crisis in astrophysics. According to well established theory, the sun's heat is maintained by a series of thermonuclear reactions deep in its interior. Although conditions in the nuclear burning region of the core cannot be observed by any conventional technique, such reactions should produce neutrinos, which we can detect (at least in principle) on Earth. However, a search for such neutrinos over the past 15 years has failed to show them (see "Our Sun", January 1978, and "The Shaky Machine", February 1978).

"But is the current sun 'normal'? It should be producing neutrinos and it simply isn't."

There seems no escape from the conclusion that *either* our nuclear physics is wrong, and the reactions which maintain the sun's heat do not produce the predicted neutrino flux, *or* our understanding of stellar structure is wrong, and these nuclear burning processes are not occurring in the core of the sun at present. Both possibilities have been extensively checked, and no major flaws in thinking have turned up. The least unpalatable resolution of the dilemma is that the sun today is not a "normal" star. For some reason a disturbance of equilibrium conditions has allowed the nuclear burning to go "off the boil" temporarily. This allows us to keep our faith in nuclear physics, and also to continue to believe that current theories of stellar structure generally still apply — although not to our sun as it is just now. But why should the sun be in a special state now?

There are several more-or-less bizarre ideas that could account for a temporary disruption of normal stellar equilibrium — but all suffer from a common flaw as they fail to explain why this temporary situation should exist now. Why should the period from 1960 to 1974 (the period of the absent neutrino flux) be a special case? It is, after all, anathema to scientists to invoke "special circumstances" to explain observations. Let's take a close look at one of the theories, however, and show how it might account for the disturbed state of the sun over the past few thousand years.

"A final answer must await development of more sophisticated computer modeling techniques."

Into the Core of the Sun

Gravity holds the sun together. The weight of overlying layers, in fact, confines the prodigious energy released in the core by nuclear reactions. Gravity also determines the basic timescale under consideration. Because light leaking from the center of the sun to the surface diffuses outward very slowly — characteristically taking some tens of millions of years — changes in the core are not soon obvious as changes in solar output. Matter is nearly transparent to neutrinos generated in the solar core, however. Traveling at the speed of light, neutrinos pass through us about eight minutes after leaving the solar core. Thus a sudden change in the sun's structure sometime in the past 10 million years could account for the absence of neutrinos while leaving the sun outwardly "normal".

But is the current sun "normal"? It should be producing neutrinos and it simply isn't. In 1972, William A. Fowler of Cambridge University in England proposed that mixing of the material in the core of a star might affect its nuclear reactions — even though mixing normally does not happen. There seems to be a consensus among astrophysicists that if such mixing does take place, the result

Between the stars lie vast dark clouds of dust and gas. This view toward the central regions of our galaxy does not show those central regions — they are hidden behind the obscuring material lying along the inside edge of our sun's spiral arm. Compare this picture to the one on pages 52 and 53 — an edge-on view of another spiral galaxy. Harvard College Observatory photograph.

will be that nuclear burning is temporarily "switched off" in just the way required to account for the present absence of solar neutrinos. Leaving aside the question of whether sudden mixing in the sun might occur through the *internal* development of instability (that is, by itself), and the puzzle of why such instability should occur just when there are people around to witness it, is there any evidence of an *external* effect which might have disturbed the sun sufficiently to produce the mixed core conditions postulated by Fowler?

Through a Cosmic Dustcloud

Once again, an old idea has recently undergone a revival. More than 50 years ago Harlow Shapley suggested that the position of the solar system in its orbit around the galaxy could be linked to ice ages and variations in solar luminosity. Let's imagine, for a moment, the sun as it journeys around the galaxy, ducking through the spiral arms of the galaxy as it goes. As it moves through a dustcloud, it's bound to accumulate some material through its gravitational attraction. Material falling to the solar surface will release its gravitational energy as heat, increasing the surface brightness of the sun. Infalling dust can, under reasonable conditions, account for a temporary brightening of the sun by about one percent, and increases of more than 100 percent are possible for short periods (about 50,000 years) as it travels through the densest clouds. Sizable effects lasting 100,000 years are plausible at times when the sun passes through the compression lanes of dust and gas associated with the spiral arms of our galaxy — *and we have just emerged from such a region.*

> ***"The least unpalatable resolution of the dilemma is that the sun today is not a 'normal' star."***

The solar system crosses a spiral arm every 100 million years; it takes around a million years to cross the compression lane "ahead" of the arm, with about 10 million years to cross the region of bright stars and stellar associations more conventionally associated with the spiral structure. Our solar system is about to enter the Orion arm, having recently passed through the associated compression lane — and perhaps having passed through the unusually dense material of the Orion nebula itself. Earth's climatological record (an irregular history of ice ages and warm spells) suggests that there has been a disturbing influence affecting solar luminosity over the last million years — one which ended a few tens of thousands of years ago. If this external influence did affect the solar interior significantly, normal conditions haven't returned and we should not expect to detect solar neutrinos today.

How Can the Surface Affect the Core?

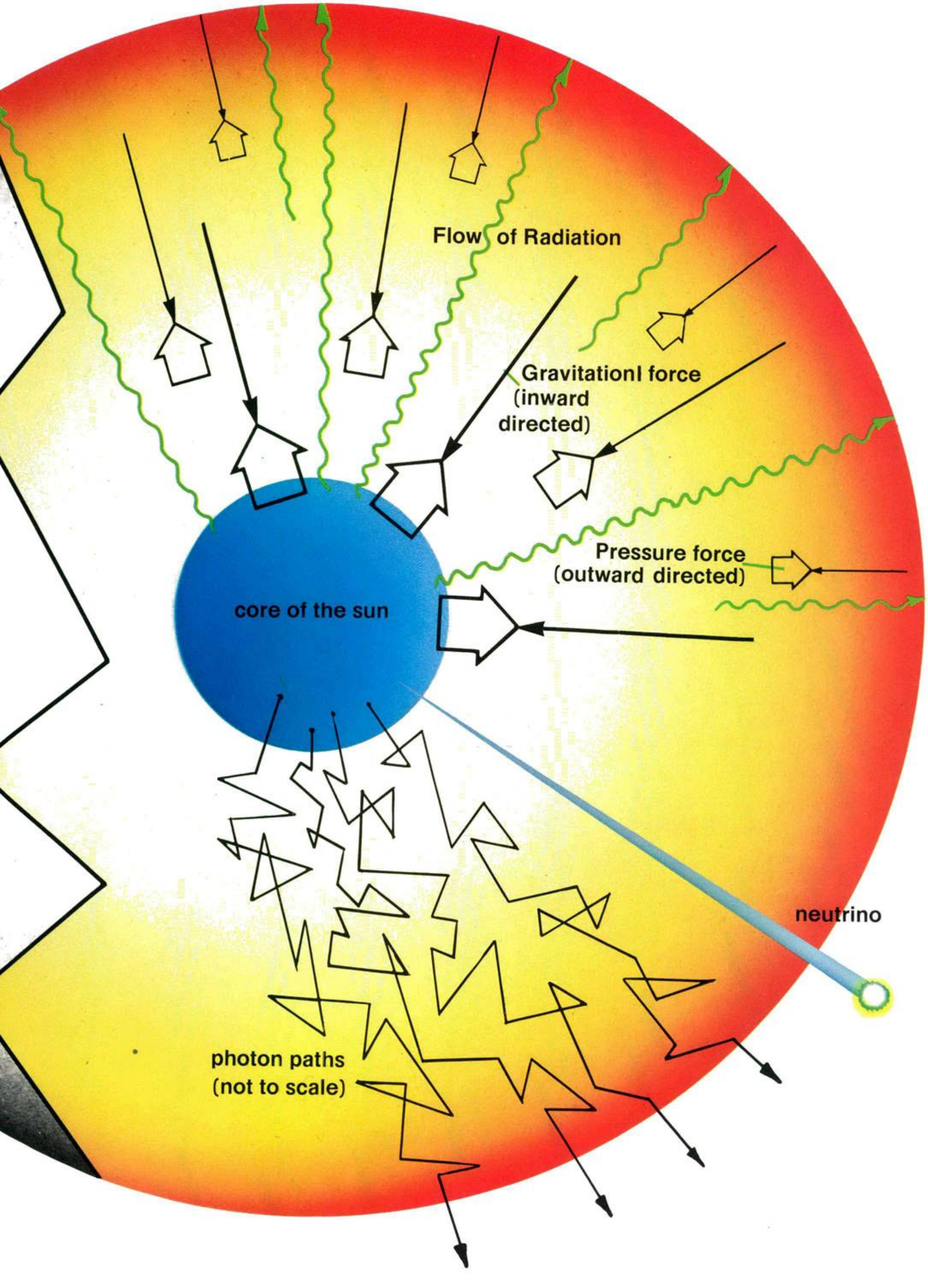
An immediate reaction is that it's difficult to imagine even huge disturbances in the outer layers of the sun having any profound, long lasting in-

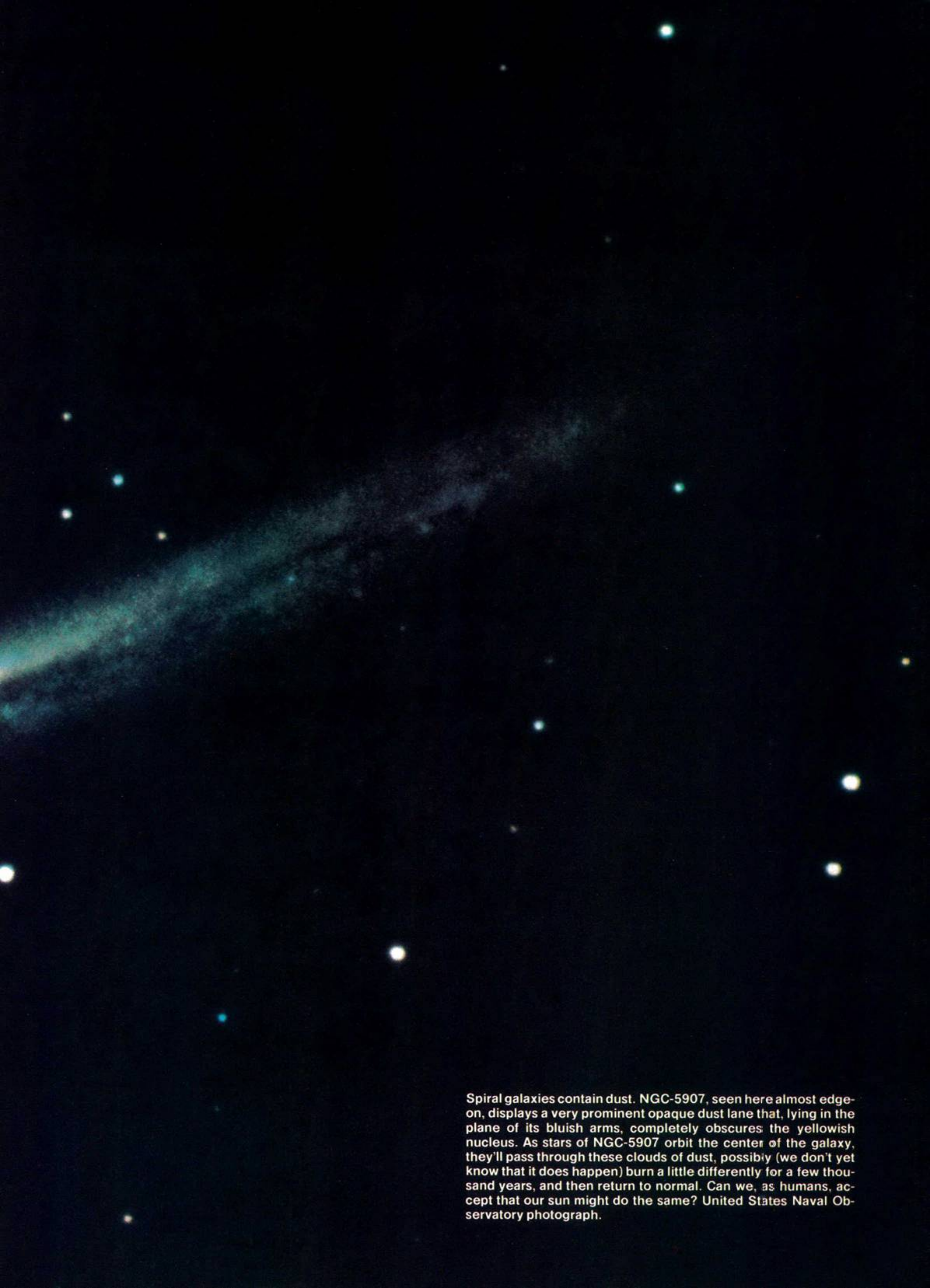
The Solar Balance

Like most stars, the internal forces in the sun are balanced everywhere in the star. The major forces in a star like the sun are hydrostatic pressure, which would cause the inner layers of the star to expand if gravity, the weight of the overlying layers, did not balance the pressure force. Radiation pressure also contributes an outward force. If the forces become unbalanced, material has to move. In the classic picture of a star like our sun, the only movement is convection near the surface. The deep layers are stable, in equilibrium.

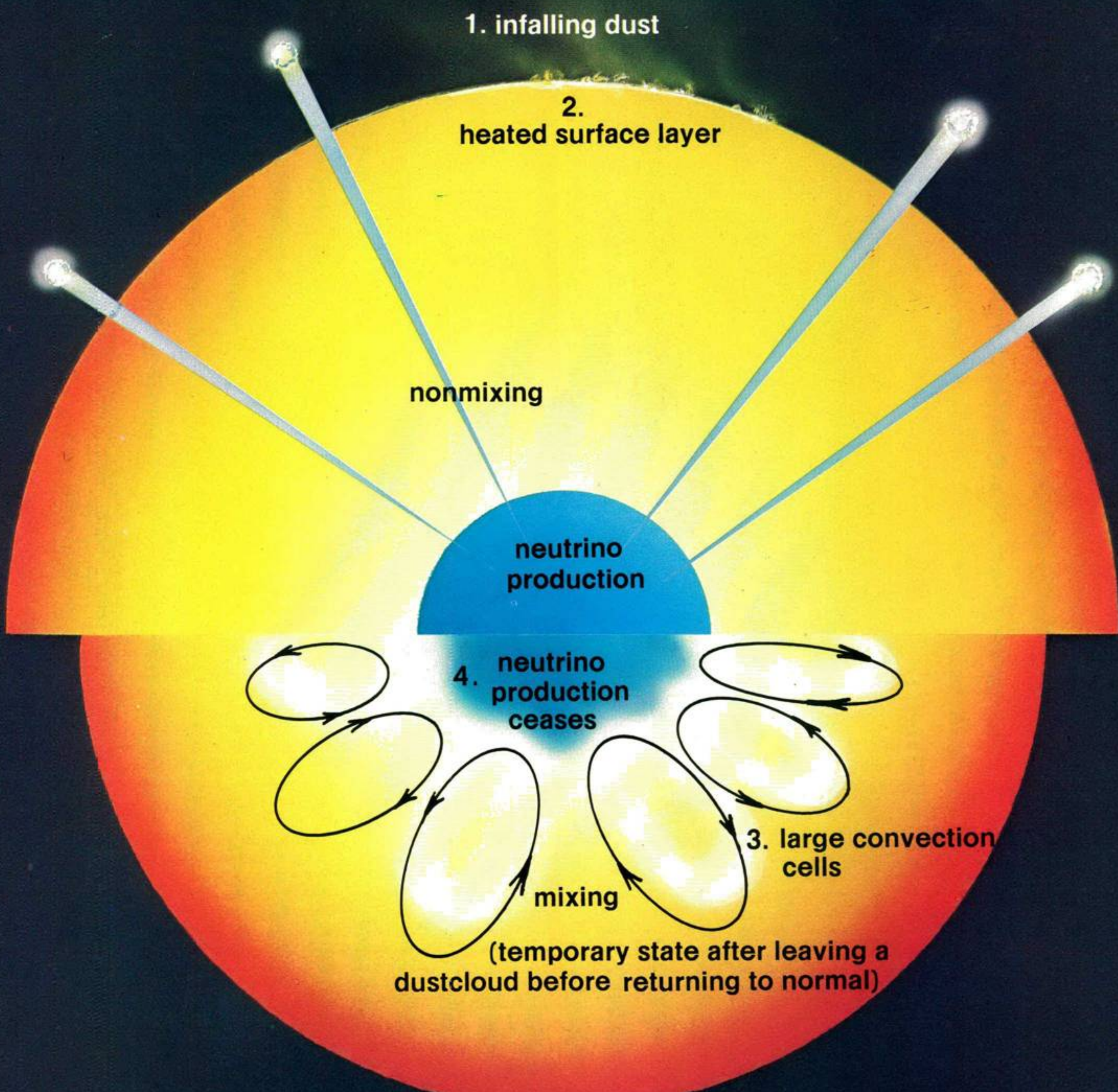
The Neutrino Signal From the Core

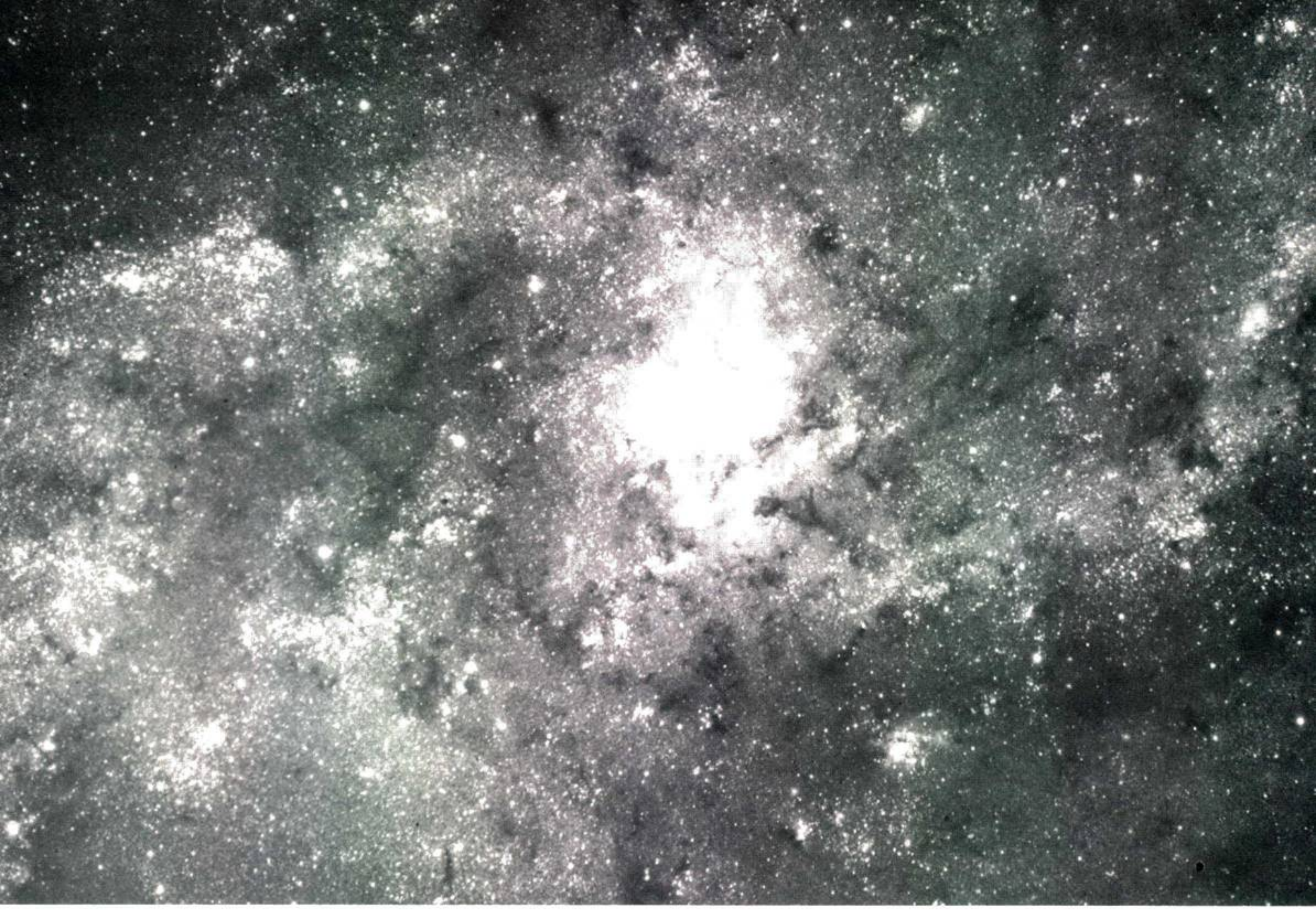
Photons — particles of light — take a torturous path out of the sun as they scatter again and again from electrons in the gas of the solar interior. Neutrinos, on the other hand, pass through the bulk of solar material almost as if it wasn't there. Changes in the solar core are undetectable with light because it takes a long time — millions of years — to diffuse from the solar core to the surface. But if we detect neutrinos (which travel at the speed of light), we'll know what's happening inside the sun immediately. Mysteriously, though, the neutrinos that scientists expected to detect have not been found.


Flow of Radiation
Gravitationl force
(inward
directed)
Pressure force
(outward directed)
core of the sun
neutrino
photon paths
(not to scale)



Spiral galaxies contain dust. NGC-5907, seen here almost edge-on, displays a very prominent opaque dust lane that, lying in the plane of its bluish arms, completely obscures the yellowish nucleus. As stars of NGC-5907 orbit the center of the galaxy, they'll pass through these clouds of dust, possibly (we don't yet know that it does happen) burn a little differently for a few thousand years, and then return to normal. Can we, as humans, accept that our sun might do the same? United States Naval Observatory photograph.


1. infalling dust
2.
heated surface layer
nonmixing
neutrino production
4. neutrino production ceases
3. large convection cells
mixing
(temporary state after leaving a dustcloud before returning to normal)



Left: Before and during the accretion of dust (upper half of diagram), the sun should remain stable, generating energy and neutrinos in its core. Upon removal of the dust (after the sun escaped the dustclouds), a presumed period of readjustment might result in mixing of the core (lower half of diagram), causing a temporary turn off of solar energy generation and neutrino production. But we don't know that this is what is happening; it is, at best, an educated scientific guess. Diagram by Mark Paternostro. Above: In the face-on spiral M-33, dust (visible as small dark patches) and spiral arm structure are intimately related. Hale Observatories photograph.

fluence on the deep interior. Gravity provides a safety valve for the sun; its layers can expand or contract to accommodate relatively large luminosity changes without changes in the energy production mechanisms of the interior. But intuition may be misleading since the radiative interior of the sun is not all that far from convective instability (beginning to mix).

> ***"...it's difficult to imagine even huge disturbances in the outer layers of the sun having any profound, long lasting influence on the deep interior."***

Qualitatively it seems reasonable to expect that infalling material will heat a zone at the surface, expand the star a bit, drop its central temperature, and slow its nuclear reaction rate a bit. When infalls stop, however, it is tantalizing to speculate that this is just the condition required to allow enough mixing to "turn off" the neutrino reactions in the core.

> ***"There seems no escape from the conclusion that either our nuclear physics is wrong...or our understanding of stellar structure is wrong...."***

The trigger for instability, then, is not the *beginning* of accretion but the *end*. Since we've just emerged from the dust lane associated with the Orion arm (within the past 100,000 years, that is), this suggests we are at the beginning of the resulting roughly-10-million-year period of solar adjustment. Perhaps this lends some urgency to the question of just how the sun will relax to its normal state.

A final answer must await development of more sophisticated computer modeling techniques. It clearly would be naive, and quite likely wrong, to draw the intuitively obvious conclusion. Gravity plays a vital role in determining the existence and structure of the sun, the influence of infalling material on the luminosity of the sun, the sensitivity of the core to mixing and the timescale over which the sun will recover. The questions raised are too many, too great, and too incomprehensible to the average person to elicit more than "gee-whiz". Nonetheless, these problems stimulate thought — and they vitally concern all mankind.

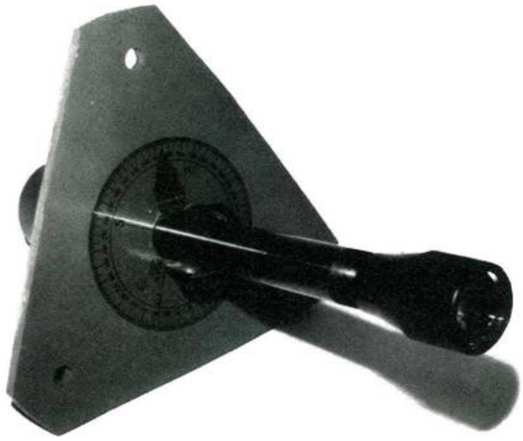
ACCURATE CELESTIAL POLE FINDING
The Key to Good Astronomy

DOES IT FRUSTRATE YOU? Is it stealing valuable time from your observing and photographic sessions? Are you always positive you are lined up on the Celestial Pole? Solve your problems with our PRECISION POLAR AXIS FINDER*.

A quick, easy, positive, no-guessing method. Just sight the 4-power cross hairs on Polaris and the correct built-in optical offset assures you of exact polar alignment every time. Now available for German Equatorial Mounts as well as fork-type mounts such as CELESTRON, DYNAMAX, QUESTAR, and others. We also rent our units for one-time use on permanent installations.

The PRECISION POLAR AXIS FINDER* is superior to special telescope finders, with special circular or offset cross hairs; these are totally dependent upon a very accurate declination setting for their correctness.

GERMAN EQUATORIAL $67



CELESTRON $69

We Are at the Cutting Edge of Advanced Technology with Our Custom-Engineered Astronomical Equipment

Our research and development has produced the following widely acclaimed astronomical products: SOLAR SKREEN® — Unsurpassed SAFE solar filter unit; LUNA-SHADE* — Comfortable moon viewing; STERE◉◉CULAR* — Unique, spectacular three-dimensional type viewing; ASTRO-TULE* — A neat astro-photographic device for focusing; Adjustable LED Illuminated Cross-hair Guiding Eyepiece with built-in battery; Sturdy, lightweight, low-cost Equatorial Drive head for cameras or small scopes; STAR-TRAP® — Rich-Field Astrocameras; and now the CELESTIAL NAVIGATOR* — A two-axis digital readout with optical shaft encoders for the ultimate in locating objects with ease. We are now working on a voice-actuated microprocessor to go with the CELESTIAL NAVIGATOR*; with this device you can command your scope to "Find M13" and **zap**, it will do it!

We invite you to touch the fringes of infinity with our Super Celestron scopes and custom-engineered equipment.

WE HONOR MASTER CHARGE AND BANKAMERICARD.
MONEY-BACK GUARANTEE ON ALL PRODUCTS WE SELL.

Financing
Available

ROGER W. TUTHILL, INC.

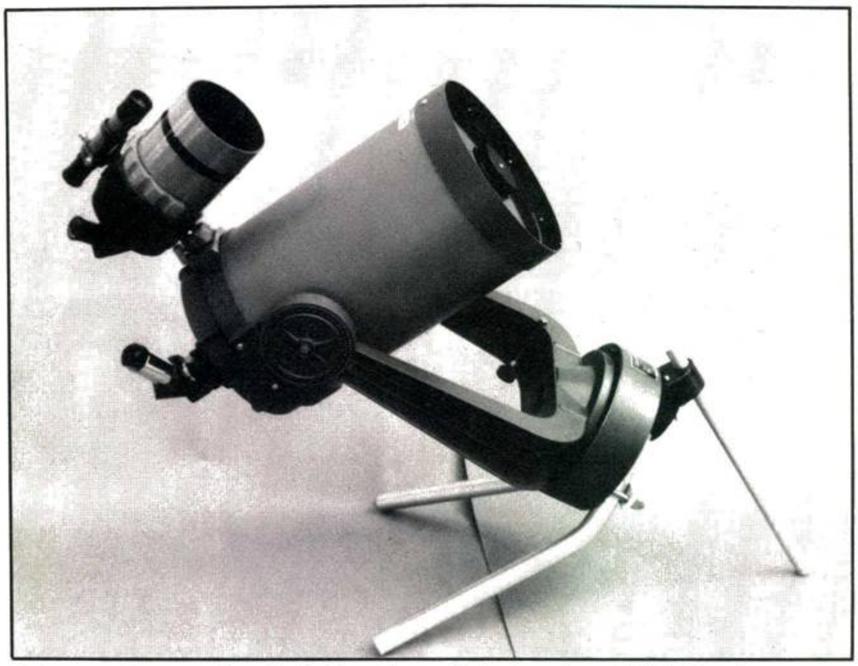
Free Catalog
*Trade Mark

Box 1086A, 11 Tanglewood Lane, Mountainside, N.J. 07092

Telephone 201-232-1786

STRAIGHT TALK ABOUT TELESCOPES

No telescope system is perfect in every design detail-no, not even the Famous Celestron Line of instruments. However, we believe, for most people a Celestron Telescope combines the best overall KEY features and benefits when compared to other competitive units.



Celestron 90 on an Omni-Axis Mount on a Celestron 8 on a Mini Mount.

Why not take advantage of our wide experience in building and grinding the optics for more than a dozen Newtonian, Maksutov, and Cassegrainian scopes with apertures up to 20 inches. We understand telescope design and can tell you the strong and weak points of each type of system — Reflectors, Refractors, Maksutov, Cassegrain, and Schmidt Cassegrain.

For instance we can tell you — Why a Schmidt Cassegrain should have an aluminum tube instead of an insulating non-conducting phenolic resin laminate plastic tube, why you never need to level your tripod, why sand castings aren't as good as die castings, why you need a large finder, why an F/15 system makes a good planetary scope but a poor deep sky astro-camera.

Call for our review of all commercial systems and their relationship to your individual needs. We specialize in helping people.

Send a S.A.S.E. for our NEW pamphlet
TUTHILL'S TWENTY-TWO TELESCOPE TIPS.

WE HONOR MASTER CHARGE AND BANKAMERICARD/VISA.
MONEY-BACK GUARANTEE ON ALL PRODUCTS WE SELL.

Financing Available

Free Catalog

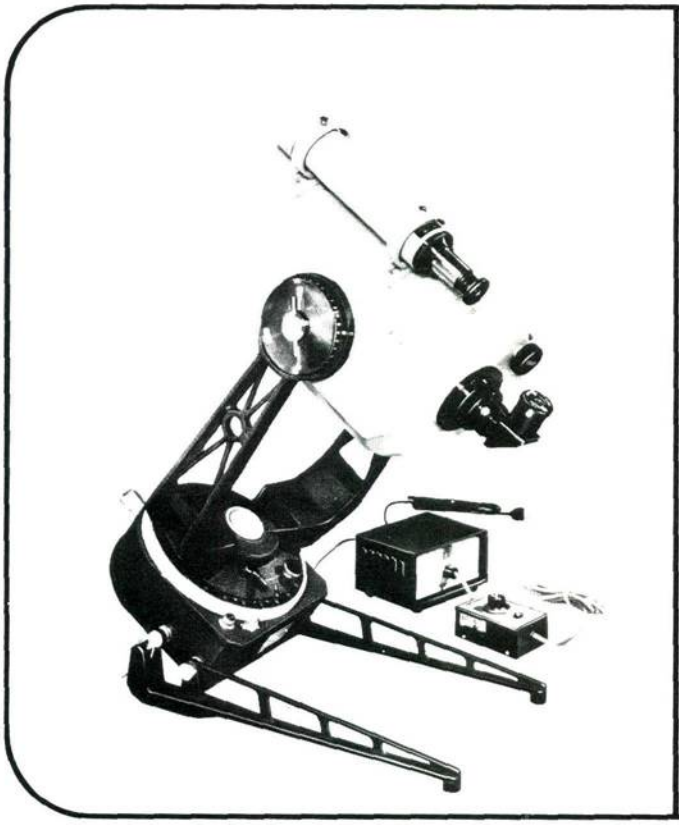
*Trade Mark

ROGER W. TUTHILL, INC.

Box 1086A, 11 Tanglewood Lane, Mountainside, N.J. 07092
Telephone 201-232-1786

Performance is the First Reason You're Proud to Own a Criterion

In telescopes, "excellence is as excellence does." Our Criterion instruments, with unsurpassed optics, rank among the world's most widely praised, because they perform brilliantly, reliably and with satin-smooth, effortless ease. The more demanding the conditions of use, the more you appreciate the ability of your Criterion to deliver exciting results. Whichever advanced design telescope you select, you get a superbly engineered instrument, guaranteed unconditionally. When you compare the pleasantly surprising prices you find further reason to choose Criterion. Please note that they are not "base" prices, but include everything described AT NO EXTRA COST. Only Criterion's leadership in efficient, modern precision production makes these prices possible.



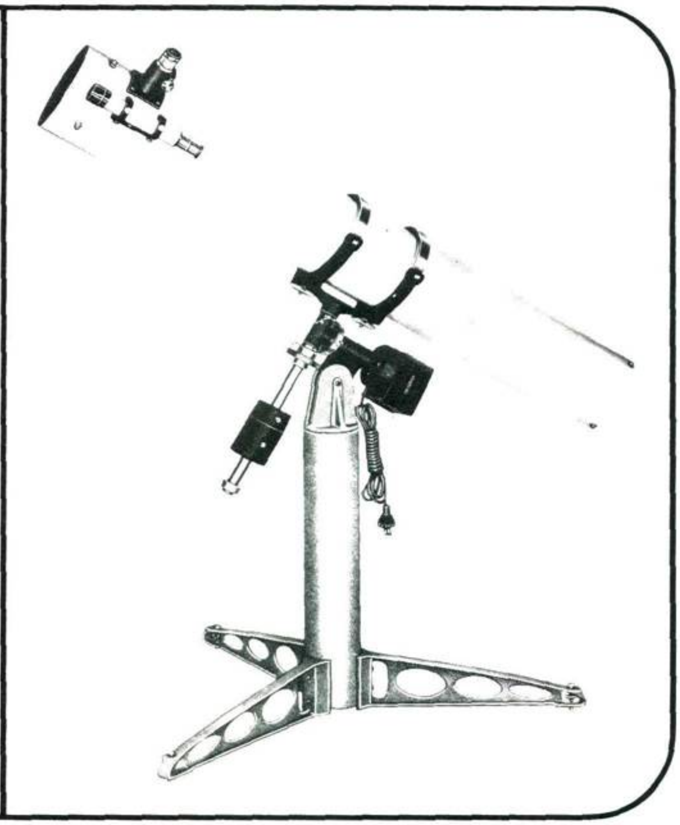
Dynamax® 8 8-Inch Schmidt-Cassegrain

**For Spectacular Results—Effortlessly.
Extra Features Without Extra Price.**

This "never before" telescope created by Criterion gives you Schmidt-Cassegrain advantages at their best: full 8" aperture, wide field, with flawless resolution, yet weighs only 30 pounds for one-hand portability! It offers unprecedented versatility for viewing, superb telephotography, terrestrial uses, or technical applications. The exquisite optics, combined with super-precise electric drive plus variable drive corrector, combine to insure unsurpassed, unequalled ease of use because the extra features so necessary for superior results are designed-in and built-in . . . and INCLUDED in the price! ☐ AC, DC, and manual drives (variable, not just solar). You can easily dial in lunar, solar, sidereal, planetary etc. rates while observing for extra long monitoring. ☐ Large 8x50 finderscope has micrometer screw focusing ☐ Toggle switch with pilot light ☐ Engraved setting circles, observable from viewing position ☐ 3 eyepieces included ☐ Star diagonal, latitude adjusters, photo and telextender adaptors, and custom, fitted case. Ready for Total Performance with nothing else to buy!

As described, complete. FOB Hartford, Conn.
Shipping wt. 65 lbs. Express charges collect.

$875



Dynascope® RV-6 6-Inch Newtonian

**For Exciting Viewing, Superb Value.
Price Includes Built-In,
Precision Electric Drive!**

Professionals and astute amateurs and school or college users by the thousands know the breathtaking performance, this pace-setting telescope achieves. ☐ Exquisite optical system includes f8 parabolic aluminized mirror, guaranteed to reach all theoretical limits of resolution and definition ☐ Highly accurate Electric Drive uses regular AC, has smooth, self-acting clutch, permits manual operation ☐ Two 1¼" eyepieces, 70X and 140X, included. (others available) ☐ Highly stable equatorial mount with solid tripod, adjusts easily for any latitude ☐ Engraved setting circles for both right ascension and declination ☐ Tube rotates for adding cameras and comfortable viewing Easy, quick portability ☐ Smooth, brass rack-and-pinion focusing ☐ Handsome, white 50" Bakelite tube maintains perfect collimation ☐ 6x30 finderscope ☐ Fine workmanship throughout.

As described, complete.
FOB Hartford, Conn. Shipping wt. 77 lbs.
Express charges collect, $15 crating charge.

$249.95

**Prompt shipment on both models. If you wish, phone us for delivery date.
To place your order, or request literature, write or call:**

Criterion Manufacturing Company

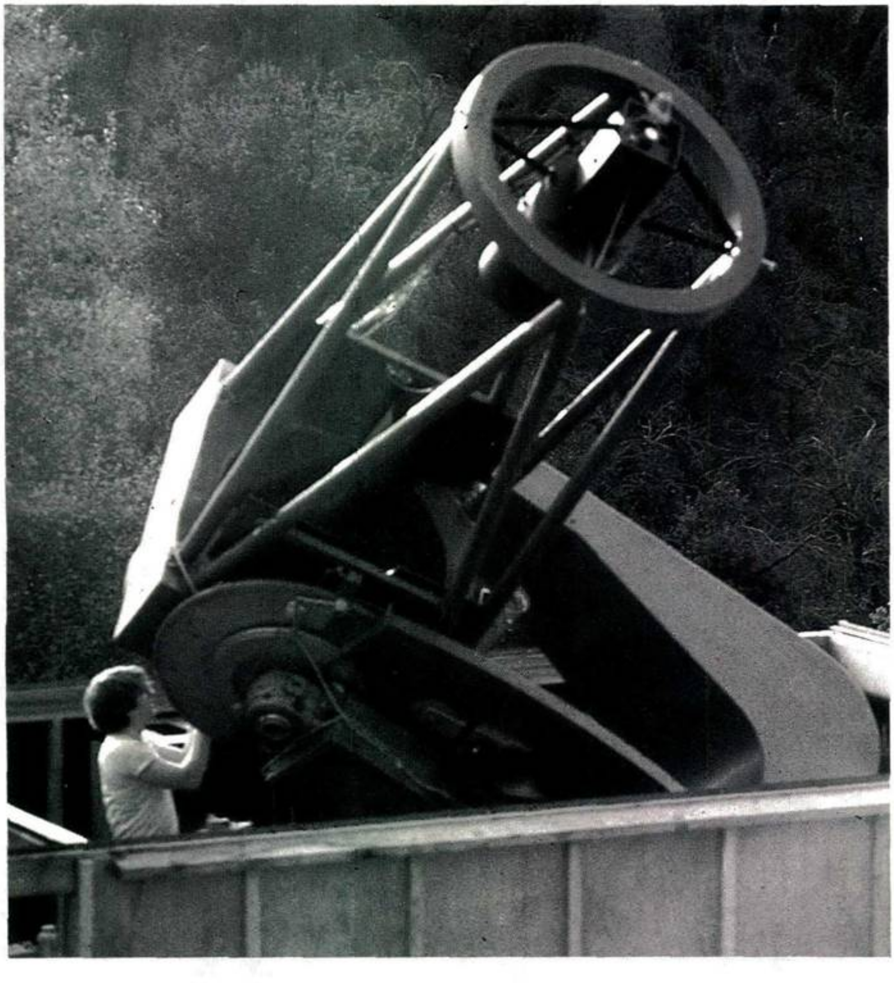
**Dept. CAS-66 620 Oakwood Ave., W. Hartford, Conn. 06110/Phone: (203) 247-1696
In New York, Robert T. Little, Eastern Sales Manager (212) 834-1888**

Astronomers Combine Efforts To Build, Operate Observatory

Last October, a small but intrepid band of astronomers stood at a site deep within the Los Padros National Forest and gazed upon the culmination of six years of dreams, schemes and ceaseless determination — the Monterey Institute for Research in Astronomy (MIRA).

The main object of their interest was a highly sophisticated 36 inch telescope. Its arrival at the site, in the hot, dry Carmel Valley in California, marked the fulfillment of an ambitious project that began 2,000 miles away in Ohio.

The astronomers, Craig Chester, Albert Merville, Bruce Weaver, Hazel Ross, and Cynthia and Nelson Irvine, are all doctoral graduates of Case Western Reserve University in East Cleveland, Ohio. Six years ago they faced graduation and the unnerving prospect that they would be unable to find jobs in their chosen profession.



Dr. Nelson J. Irvine is dwarfed next to the towering structure of the 36 inch (.91 meter) telescope, the prize possession of the Monterey Institute for Research in Astronomy (MIRA). The institute, located in the Los Padros National Forest, was founded by six doctoral graduates of Case Western Reserve University. Photograph by Bruce Weaver.

"The next step was an abyss," said Albert Merville, 38, and the senior member of the group. "Funds for astronomy had declined during the Nixon years, and there were just no decent positions open."

The alternatives, as they saw it, were menial teaching jobs in small universities with little or no hope for meaningful astronomical research.

Craig Chester, 35, thought the best he could look forward to seemed to be "a crazy life unrelated to why I was originally interested in astronomy". Chester, Merville and the others studied together in the "cloistered" atmosphere of Case's Warner-Swasey observatory. Located on property bequeathed to the university by a telescope manufacturer, the observatory (and the students who worked there) was relatively isolated from the main campus.

In the spring of 1971, the close-knit students discussed their dim futures. The talk centered on how they could maintain some contact with hands-on astronomy.

"The first idea — mind you it developed rapidly over a few short weeks — was to buy a small telescope built by some amateur at home," Chester said. "Very often amateurs are better at making telescopes than at using them. From there the telescope grew from a 16 inch, to 20, to 24, until we finally ended up selecting a 30 inch telescope!"

The plan expanded to include an observatory, which required a committment of time and money. The six aspiring astronomers verbally pledged themselves to the project for a minimum of two years past their graduation,

MIRA *continued on page 61*

NASA Funds Mobile Laser

NASA recently approved funding for a small traveling telescope designed to bounce laser beams off satellites. The highly transportable "ranging station" will be used to monitor motions around geological faults, such as the controversial San Andreas fault running down the western coast of North America.

Ranging with lasers is a relatively new technique used for measuring distances. The transportable station will use a 12 inch telescope to aim and focus light from a laser. The laser beams will be fired toward the LAGEOS (Laser Geodynamic) satellite, which is stationed in a stable, high altitude Earth orbit. Bouncing off the satellite's reflective surface, the light will return to Earth, some of it re-entering the telescope. There its flight time can be measured and recorded.

Measurement of the flight time makes it possible to determine not only the distance to the satellite, but also the exact shape of its orbit. After making a large number of ranges (or distance measurements) over an extended time period, it's possible to use the satellite as a reference point in space from which to monitor movements in Earth's crust.

The transportable station will be developed and built by astronomers and engineers at the University of Texas' McDonald Observatory. A similar ranging program has been conducted at McDonald since 1969. In that program, the 107 inch telescope is used to bounce pulses of laser light off reflecting panels on the surface of the moon (see "The Revolution in Astronomy", ASTRONOMY, November 1977). The panels were among the ALSEPS (Apollo Lunar Scientific Experiment Packages) placed on the moon by Apollo astronauts.

According to Dr. Eric Silverberg, director of the lunar ranging program at McDonald, the station's designers will benefit greatly from their experience with lunar ranging. Although other satellite ranging stations exist in the United States and foreign countries, those stations rely on more intense pulses of laser light. In this way, they retrieve relatively large amounts of light back at the telescope.

The mobile station, on the other hand, will be using a small telescope and weaker pulses of light. The amount of returned light will be very weak, Silverberg said, but the McDonald team has learned to work with small returns during their experience with lunar ranging. Often during laser firings toward the moon, only a single photon of light returns to the telescope in each minute of near-continuous laser firing.

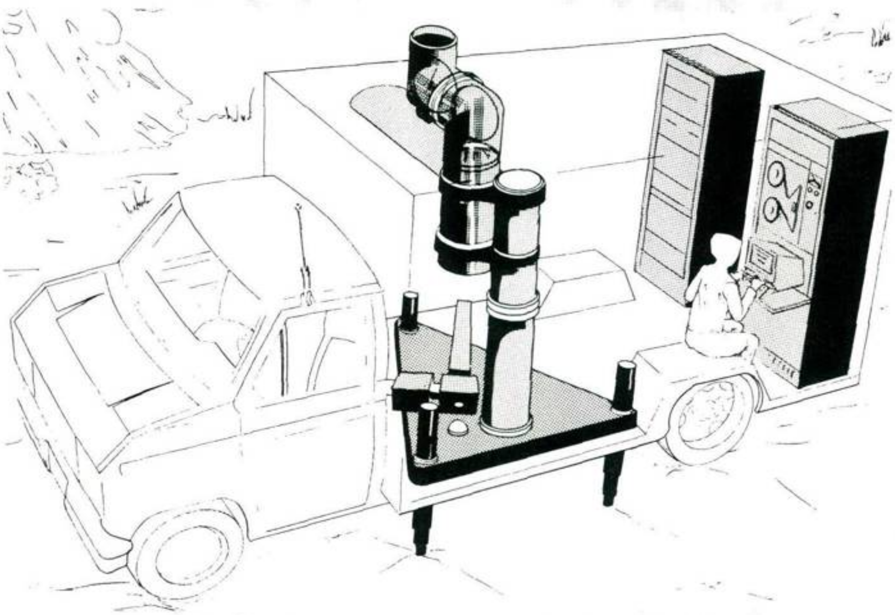
Using the weaker laser pulses has certain safety advantages, said Silverberg. He pointed out that there would be no need to use radar to watch for aircraft passing over the transportable station, a precaution taken during some laser firings.

Furthermore, he said, the small scale of the station will make it economical to build and operate. It's possible that in the future other such stations will be built, to guarantee more extensive coverage of geological motions.

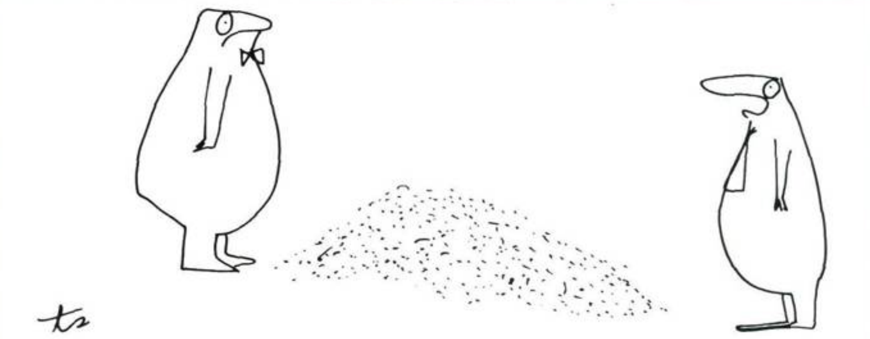
The greatest advantage of the station's size is the extreme ease required to move it from site to site. The station will ordinarily travel on back of a small truck, although it is possible to detach it from the truck for travel by air. The plan is to have the station stay two or three days at each site, making ranging measurements. It will then return to the sites, about once a year, to determine whether the ground at each spot has shifted.

The transportable ranging station is expected to be in operation by the end of next year. Activities of the mobile station will be coordinated with the lunar ranging program at McDonald, which has already been used to test some predictions of general relativity and to establish with high accuracy the exact size and shape of our moon's orbit.

Continuation of both programs, said Silverberg, will enable us to monitor many of the small but important changes in Earth's crustal plates.



A transportable ranging station is shown here equipped with a 12 inch "elbow" telescope and a green laser. The station is completely mobile; it can be used on the back of a small truck or transported by air. Drawing by Jim Reedy, courtesy McDonald Observatory.



"Another thing you should remember about grinding a lens for a 158 inch telescope — you've got to know when to quit."

MIRA *continued from page 59*

and began to consider locations, means of support and telescope designs.

After consulting topographical maps in the Cleveland library, the Los Padros site was chosen. They decided the observatory would support itself by operating a mail order bookstore. In March 1972, less than one year later, the Monterey Institute for Research in Astronomy, a nonprofit institution, was incorporated in California.

The group's efforts that year stirred up considerable interest within the astronomical community. Weaver and Merville were invited to give a presentation to the 1972 meeting of the American Astronomical Society. At that meeting MIRA received a "shot in the arm".

"Weaver cornered Martin Schwarzschild of Princeton at breakfast, and ended up with a commitment for the loan of a 36 inch telescope. That's where our telescope stopped growing," explained Chester.

Schwarzschild arranged for MIRA to borrow, for an indefinite period, a high quality 36 inch telescope originally intended (but never used) as backup for a NASA project. Soon after, the group obtained an exceptionally well-designed and well-manufactured mirror that was intended for use in a balloon at extremely high altitudes.

By the end of 1974, all six founding members and their families had moved to California, taking odd jobs for support. MIRA landed a $76,000 grant from a private foundation, the Research Corporation, to cover construction of the telescope, and through donations accumulated new and used equipment worth more than $100,000.

Merville is pleased with the help the Institute has received from the established astronomical community. "We've been greatly heartened by their support. Surely, we couldn't have made it without them."

"I am amazed at the equipment we have," Chester added. "We have a state-of-the-art telescope and our mirror is one of the best. We have one of the finest observing sites in the world, with both state-of-the-art detectors and controls."

The Research Corporation granted money to build the telescope on the strength of endorsements by several prominent astronomers. Included among the group was Bart Bok of the University of Arizona, who at the time was president of the American Astronomical Society. Bok and his wife Priscilla also donated their astronomical library to the new institute.

The MIRA group designed its own computer control system for the telescope which, according to Merville, is one of the first telescopes *designed* to be computer controlled. The design saves the MIRA researchers large amounts of time, as noncomputer controlled telescopes require manual star alignment — a process that could take 10 to 30 minutes for each star. On the MIRA telescope, star coordinates can be programmed beforehand and carried out at the press of a button. The five minicomputers in the system came from a major semiconductor manufacturer whose vice president is an amateur astronomer.

Saving time is a vital concern to the MIRA researchers because their preliminary project is a five year, 100,000 star spectral photometric survey of the brightest stars in the galaxy. Using the photoelectric equipment they have assembled will enable them to determine the abundance of heavy metals in the stars and their relative brightnesses and distances. The survey will act as an adjunct to the widely used **Henry Draper Catalog,** on which stellar classifications are based, and could provide an unparalleled body of data of rare star types.

The idea for the survey was proposed by Nancy Houk, who attended Case Western at the same time as the MIRA researchers. Their study will serve as a complement to a similar 10 year study she is conducting for the University of Michigan.

According to Merville and Chester, the project was chosen for two reasons — the first as a means of paying their dues to the astronomical community. "Astronomers live by their catalogs," said Chester, "and the **Henry Draper** is an old catalog in need of a contemporary update."

The catalog was first compiled at Harvard University in the 1880s by E. C. Pickering and A. Maury, and then revised to the form used today by Annie Jump Cannon at the turn of the century. Cannon poured over thousands of photographic plates while formulating her stellar classification system. In the 42 years Cannon worked at Harvard, she discovered over 300 variable stars and indexed 300,000 spectra. Unfortunately, she toiled at Harvard at a time in which women were hired as "computers" — indexers of plates — and her name did not appear in the catalog. Her presence was finally officially acknowledged by the university in 1938, when she was 75 years old.

It is this study that MIRA plans to add to — a task that is virtually impossible for most astronomers. Because of the scarcity of large observatories and the considerable number of astronomers applying to use them, time is usually allocated in brief chunks — 10 to 20 hours over a few nights. Most astronomers feel the pressure to undertake projects likely to yield publishable results quickly. Having both the facilities and the time available gave the MIRA researchers a solid second reason for choosing this particular project.

"We are not under the publish-or-perish gun," said Chester. He admitted, however, there was a bit of self-interest in the project selection. "There was no doubt that we had to select a project astronomers would be interested in and would lead them to want to fund us. When they asked us what the money was for, we couldn't just answer, 'Well, uh, astronomy!'"

Merville says only half the Institute's time will be spent on the Draper project; the remainder will be open for individual projects.

The researchers, Chester said, are now in the process of "tweeking up the optics" on the telescope, and planting grass around the observatory confines, as a fire recently swept through the Carmel Valley.

When asked if he would encourage other astronomy graduates to follow in MIRA's footsteps, Merville said, "They should think long and hard about it, and they shouldn't go into it starry eyed."

Jupiter Orbiter Probe Named for Galileo

A 1982 NASA mission, previously known as the Jupiter Orbiter Probe, has been formally designated Project Galileo.

The purpose of the mission is to orbit a spacecraft around Jupiter and to send a probe into its atmosphere. The new designation honors Galileo Galilei, the 16th century Italian astronomer who was the first to observe the planet by telescope and who discovered the moons of Jupiter.

The mission is composed of an orbiter which will circle the planet for at least 20 months, and a probe which will plunge deeply into Jupiter's atmosphere. The orbiter will carry 10 instruments, and the probe will carry six.

Galileo is the first planetary spacecraft to be named for a person, although NASA's Orbiting Astronomical Observatory 3 (OAO 3) was christened Copernicus after it was launched in 1972.

Peering through the newly invented telescope, Galilei, in January 1610, was the first to see the four larger moons of Jupiter, although he did not immediately recognize them as such. The satellites, known as the Galilean moons, are named Io, Europa, Ganymede and Callisto, after four lovers of the god Jupiter (Zeus) in Greek mythology.

Is the Gravitational Constant Changing?

Some models of the universe call for a change in the gravitational constant, G, over long periods of time to explain some features of cosmology (see "Rival Cosmologies", ASTRONOMY, March 1978). One of the consequences of changing G is that the gravity that binds the planets together would change, presumably resulting in cracks, fractures or wrinkles of some kind on the planetary surfaces.

Now three researchers at Australian National University, M.W. McElhinny, S.R. Taylor and D.J. Stevenson, have examined four major bodies in the solar system — Earth, the moon, Mars and Mercury — for evidence of expansion due to decreasing G. From their study, they have placed an upper limit on the rate at which G could be changing: no more than eight parts per trillion per year.

Earth is a poor planet to study, because other forces operating at its surface obliterate surface features older than a half billion years. Using a method based on magnetic fields recorded by rocks, however, the researchers deduced a value about two percent larger than at present for Earth's diameter a quarter billion years ago.

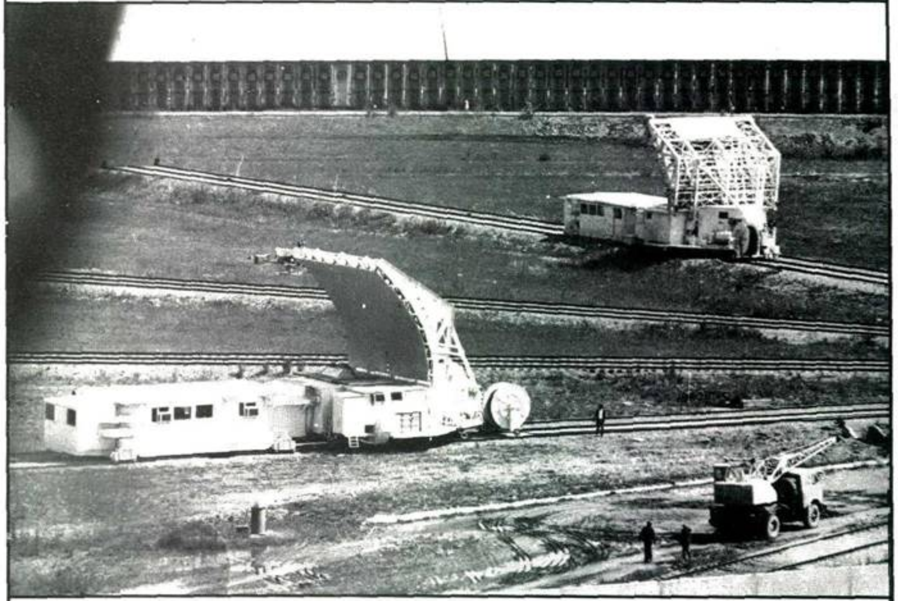
Earth's moon is a much better place to look for changes. In contrast to the dynamic Earth, the moon has been static for some four billion years. High quality photomapping enabled the researchers to place an upper limit on the moon's change in size as being less than six parts in 10,000 over the last four billion years.

Mars and Mercury both display well preserved surfaces too, excepting that volcanic activity around the Tharsis region complicates the interpretation of Martian geological history. Depending on how they interpret the results of assumed Martian histories, they find a possible small expansion of six parts per thousand from one to three billion years ago, with no changes in the last billion years.

Mercury seems to have shrunk about a mile in radius not long after forming, but there is no evidence that any expansion has occurred for the last 3-1/2 billion years.

While varying G cosmologies differ in the amount of change required in G, the geological record shown on the planets imposes severe limits. This new work seems to rule out Dirac's "additive creation" theory and Hoyle's and Narlikar's theories. Whether the varying G cosmologists can make their theories work inside the values imposed by these observations remains to be seen.

Soviets Construct Radio Telescope



Zelenchukskaya, a former Cossack settlement in the Northern Caucasus of the USSR, is the site of the newest, largest and most sensitive radio telescope in the world today — RATAN (Radio-Astronomical Telescope of the Academy of Sciences). This huge, metallic, dish shaped structure, nestled in a gravel bed and protected from high winds and outside radio interference by the surrounding mountains, has a total area of 11,960 square feet (10,000 square meters) and a diameter of more than 545 yards (500 meters). Its surface consists of 895 rectangular mirrors precisely interlocking, each capable of rotating on both a horizontal and vertical axis. The precision of mirror adjustments for very great distances is within fractions of an inch. Each adjustment is made automatically by control devices inside the "dish".

First put into operation in 1974, RATAN is divided into four sectors, each of which can operate as an independent radio telescope and conduct independent observations in different parts of the universe. Cars resembling armored railroad cars are set at the point of focus in each sector. Each car's antenna, a mirrored panel, collects signals for its particular sector. Depending on the configuration registered by the reflective units, the focus of the radio telescope changes, which is why the cars move along rails. The mobility of its mirrors, in combination with its record surface area, remarkable resolving power — even with objects at the edge of the universe, and wide radio wave reception range makes RATAN an impressive astronomical instrument. Photograph courtesy of Novosti Press Agency.

"Either we're halfway between Sirius and Procyon or you brought the wrong map folder."

COUNTER SALES

Planetariums and museums across the country are finding a new money-making opportunity with ASTRONOMY Magazine by purchasing the magazine for resale.

Astronomy clubs may take advantage of this too, since members who don't subscribe may want to purchase a single copy at meetings. In addition, if your club gives public lectures or has open house nights you have an excellent opportunity to pad your organization's treasury with extra cash from ASTRONOMY sales.

Orders are accepted from all museums, planetariums and recognized science or astronomy clubs or organizations. Bills are mailed the same day bulk orders are shipped and are payable in 30 days.

Bulk copies are sold on a nonreturnable basis, so make your first order a conservative one and increase the quantity later when you establish your level of sales. For more information write:

Nancy Faustmann, Bulk Copy Sales

ASTRONOMY Magazine

411 E. Mason St., 6th Floor

Milwaukee, WI 53202

This astrophotograph was taken just five miles from center city Philadelphia.

Astrophotographs like this were once considered impossible to achieve, but now with the help of this 52-page reference work by Joseph A. Cocozza, you can achieve exceptionally clear and detailed astrophotographs through unfavorable city skies. Techniques from thirty years experience as a professional photographer are clearly explained in this practical "how to" guide for the city-bound astronomer.

The cost of this limited edition of "Astrophotography Near City Lights," including hard-cover slip case with titled spine and data card, is $12 (that's less than the price of two rolls of 36-exposure spectroscopic film). You can begin to get excellent results before the end of your first roll. The investment will yield a big return in astrophotographs you never thought possible in light-polluted skies.

ASTROPHOTOGRAPHY NEAR CITY LIGHTS

The beginning of a new photographic adventure.

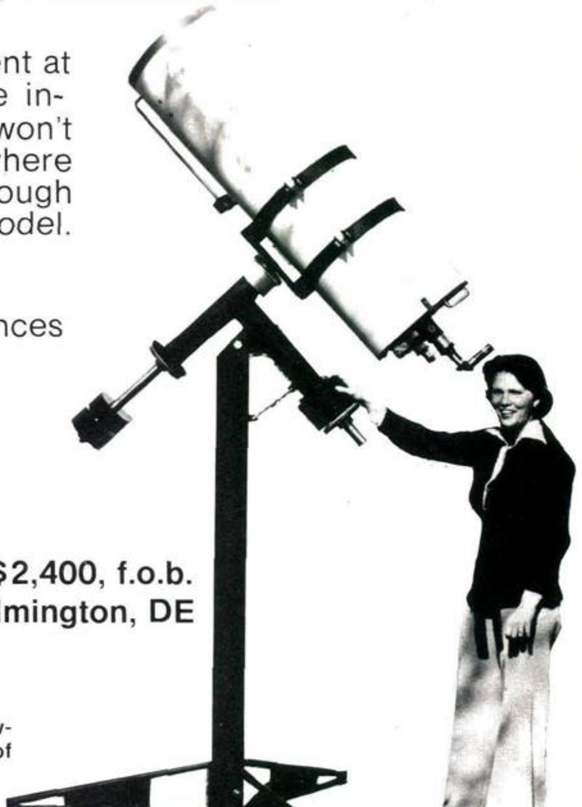
Mail check to: **Joseph A. Cocozza, Astrophotography, Dept. A, P.O. Box 335, Westville, New Jersey 08093 (609) 845-6387**

New Jersey residents add 5% sales tax. Foreign delivery, add $2.50 for Air Mail. (When ordered separately, the hard-cover slip case and data card are $2.50 including postage and handling.)

NOW!

Introducing a new 12-1/2" Cassegrain Instrument at a price you've only seen on smaller units. We invite you to compare and shop around. You won't find instruments of this size and caliber anywhere at a comparable price. Our motto of "Quality through Design" is upheld in every aspect of our 125C model. Highlights of the 125C include:

12.5" - F/15 Cassegrain optics
Extra sturdy mount machined to close tolerances
(no brittle castings)
All stainless steel shafting
precision R.A. clock drive
Manual slo-motion on declination axis
8 x 50 finder
2" photo guidescope (not shown)
2" eyepiece mount
eyepieces and diagonal
tube counterweights
fibreglas tube
durable black wrinkle finish



$2,400, f.o.b. Wilmington, DE

All instruments can be custom built to your specifications. Average delivery time is approximately 8-10 weeks upon receipt of order. Other sizes and models also available.

Send for our brochures on the 125C and see what a difference Design can make in Quality!

Send inquiries to: Optical Engineering P.O. Box 10182 Wilmington, Delaware 19850

Celestron Telescopes—Professional Quality Parts and Accessories

IMPROVE YOUR TELESCOPE'S PERFORMANCE WITH SOME OF OUR CUSTOM ACCESSORIES.

As one of the nation's leading Celestron dealers, we want to put you behind the controls of one of these fine instruments. The big news this year is the C90. Check our list of new accessories for this fine telescope.

Celestron C90 Accessories

7.5-22mm Zoom (44X-133X)	**$24.50 ppd.**
Porro Prism	**19.95 ppd.**
40mm. (25X)	**16.95 ppd.**
6mm., 9mm., & 12mm. Ortho	**each 18.95 ppd.**

NEW CELESTRON ACCESSORY CATALOGUE.
Get our free Celestron accessory catalogue and save on standard accessories as well as many of our unique products for your C90, C5, C8 and C14.

For 1978, some exciting new eyepieces to improve your telescope's performance.

For our many friends who have asked us to expand our König line, we offer the exciting 24mm. focal length König ultra-wide-field model. With a field of more than 68°, this is the ultimate in wide 1¼" eyepieces. Multi-coated, of course.

For the 2" O.D. eyepiece devotee, there is the new 55mm. Plössl. Excellent eye relief and a wide field of view. Multi-coated. C14 owners will be amazed at the performance.

16mm. König	**$33.50 ppd.**
24mm. König	**36.50 ppd.**
55mm. Plössl	**79.50 ppd.**

PLOSSL 55mm
KONIG 24mm

MIR-O-TESTER

Get a better mirror! Parabolize it with one of our fine instruments. Order your Mir-O-Tester today!

When your mirror has reached the polishing stage, give it the Foucault test with this fine tester. Our improved Mir-O-Tester offers .001" accuracy with a micrometer-type dial. Kit model is easily assembled from precision parts. Assembly instructions and zonal masks included.

Assembled **$39.95 ppd.** **Kit** **$18.95 ppd.**

DEEP—SKY EYEPIECES

Extra-wide field Kellners for breath taking views of space!

Model A With its special enlarged field lens, it yields the widest field possible. Threaded barrel.

40mm. KMA **$19.95 ppd.**

Model B Same wide field as above, only precisely parfocal. We recommend this model for eyeglass wearers.

40mm. KMP **$22.50 ppd.**

8 x 50 for Celestron

Our popular wide-angle finder with bracket for C8. Available with True Polaris North indicator reticle.

Model A (T.P.N. reticle)	**$53.95 ppd.**
Model B (Standard cross hair)	**$43.95 ppd.**

CALL US FOR FAST SERVICE

CHARGE CARD ORDERS, C.O.D.s

Call Toll Free

(800)-521-2828

all states except Alaska, Hawaii, and Michigan

(9:30 a.m. - 4:30 p.m. Mon. - Sat.)

Second Line (313) 761-0430

A NEW REFRACTOR!

Introducing the compact new 3.1" model by University Optics.

A new, compact, easy to use f/11 refractor with big telescope performance. High quality air-spaced objective. Adjustable equatorial mount lets you follow celestial objects with ease. Coated optics. Includes eyepieces, Barlow, star diagonal, erecting prism, and more. We feel this is the ideal telescope for those of you seeking an easily transportable refractor at a reasonable price. Don't delay, place your order today.

3.1" Refractor **$350.00 ppd.**

NEW DUAL FUNCTION RETICLE

The first illuminated reticle designed to meet all of your most critical guiding needs.

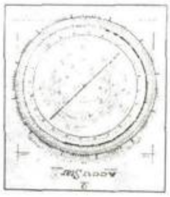
This amazing new dual-light reticle lets you select the correct color depending on sky conditions. Flip a switch for amber or special night vision green. 12.5mm. orthoscopic design. Adjustable brightness control. Focusable cross-hairs. 4 feet of power cord. Batteries included. Eyepiece weighs only 4 oz. 1¼" O.D. This fine illuminated orthoscopic will prove to be one of your most valued photographic aids. **$39.50 ppd.**

VARIABLE-POWER BARLOW

Our new Professional Series Barlow is one of the world's finest! While it was designed to fit the Celestron, this fine variable tele-negative amplifier gives flawless performance in any telescope. The lens slides in a precision brass cell allowing the power to be varied between 2X and 3X. Brass construction with a satin chrome finish. The lens diameter is 27mm. Coated optics. 1¼" O.D.

Variable Barlow **$33.50 ppd.**

ACCUSTAR



Enjoy your telescope more. Get sidereal time any place, any time, instantly!

Learn how to use your telescope's setting circles, how to point your scope, and the importance of sidereal time in astronomy. We feel that no telescope owner should ever be without Accustar. You get the Accustar instrument, Sky Finder overlay, and 90-page textbook.

$11.95 ppd.

ZOOM FROM 8.4 to 21 mm.

This is the same fine quality zoom eyepiece we have sold through the years and we have refined it even more! Built-in astro filter adapter at no additional cost. Coated lenses with precision construction throughout. 1¼" O.D. Smooth zoom action for those close-up views. Truly an excellent value. **$36.50 ppd.**

PARFOCAL EYEPIECES

Fine quality orthoscopic eyepieces at reasonable prices.

These precisely parfocal 4-element orthoscopics are unexcelled in color correction and resolution. Fully coated optics with a nice 45° field. Standard 1¼" O.D. barrel with built-in filter adapter. Whether for use in the research laboratory or in the home observatory, these are the eyepieces you can count on.

Focal lengths: 4, 6, 9, 12.5, 18, and 25mm. **each $24.95 ppd.**

PHOTO-VISUAL MOUNT

Custom engineered for the astro-photographer, this sturdy 2" O.D. mount stands less than 2¾" high. There is no vibration and no vignetting of the light cone. Fits any size reflector tube. Optional accessories include 2" camera adapters and 1¼" eyepiece adapter.

PV Mount **$45.00 ppd.**

DEEP-SKY BINOCULARS

Our 11 x 80 and 20 x 80 giant binoculars will meet your most critical deep-space viewing requirements.

We improved the quality on these popular 80mm. binoculars even more! They now feature UV coated objectives in addition to fully coated eyepieces. Perfect for astronomy or nature study. Center-focus design with a reinforcing bridge between the objectives to protect collimation. We suggest the 11-power model for rich-field observation of the stars. Rubber eyecups and camera adapter included.

11 x 80 or 20 x 80 **$145.95 ppd.**

COLLIMATION CERTIFICATE. Each instrument is supplied with a certificate of collimation showing how it conforms to our rigid astronomical alignment requirements. A University Optics first!

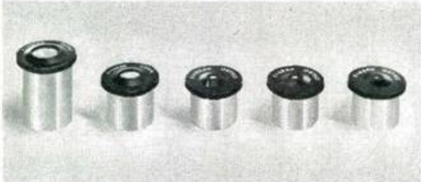
PROFESSIONAL FOCUSING MOUNTS

UNIVERSAL. Our most popular mount. We have sold this helical rack and pinion for years with excellent results. Cheap copies have appeared, but they have never duplicated its superior design. Fits all tube sizes. 1¼" I.D. **$19.95 ppd.**

VEGA 1. A truly unique mount. Mount rotates 360° on base. By removing one screw, top portion of mount can be removed for first-focus photography. Helical rack and pinion has over 3" travel. Base to fit your tube or available flat. 1¼" I.D. Thumbscrew holds ocular. **$33.95 ppd.**

VEGA 2. When professional telescope makers choose a big mount for 8" or larger scopes, this uhit fills the bill. Takes the giant 2" O.D. eyepieces as well as 1¼" O.D. units. Cast aluminum construction with helical cut rack and pinion. Thumbscrew holds ocular. The large focusing knobs make using it a pleasure. **$33.95 ppd.**

PROFESSIONAL EYEPIECES



Through the years, the ones they have all tried unsuccessfully to duplicate.

The high quality of our Professional Series eyepieces has been well established over the years in every part of the world. Camera quality orthoscopic optics with multi-coating for maximum light transmission. Warranted to equal or exceed the performance of any eyepiece sold today or your money refunded. Each comes with fitted carrying case.

4mm., 6.8mm., 10.2mm., 16mm., and 28mm. **each $33.50 ppd.**

NEW FREE CATALOGUE
GIFT WITH EVERY ORDER

UNIVERSITY OPTICS INC.
2122 E. Delhi Rd.
Ann Arbor, Mich. 48106

WEST COAST OUTLET
UNIVERSITY OPTICS WEST
P.O. Box 6038, Phone (213) 541-4331
Rolling Hill Estates, CA. 90274

ASTRO-MART

Astro-Mart is a free, reader service department available only to current, paid, noncommercial subscribers; 2 ads are allowed per year. Each ad submitted must not exceed 40 words in length (including name, address, etc.). All ads are subject to editorial review for suitability. Be sure to allow 3-4 months for your ad to appear.

in the

GULF COAST AREA

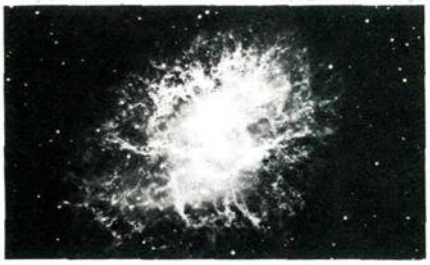
Celestron, Unitron, Meade, Mayflower, Giesler "AccuTrack®" DOAA, Vernonscope, Bushnell, Swift, Fujinon, Zeiss, and soon the new "Quantum" Maksutov telescopes.

Texas Nautical Repair Co.

3209 Milam St., Houston, Texas 77006
Phone (713) 529-3551

---

15 Billion Years in the Making!



FULL-COLOR POSTERS

SLIDES, POSTCARDS, MAPS, PRINTS
Over 700 items available.

- *THE LARGEST SELECTION*
- *THE HIGHEST QUALITY*
- *THE LOWEST PRICES*

A single source for space visuals from

- Hale Observatories
- Lick Observatory
- NASA
- U.S. Naval Observatory

Substantial discounts on quantity orders!

Write Dept. A for our catalog and free postcard.

HANSEN PLANETARIUM

15 South State Street Salt Lake City, Utah 84111

CANADIANS

EDMUND SCIENTIFIC PRODUCTS

serves Canada's needs in ***TELESCOPES*** and all related accessories.
We are also authorized
CANADIAN DEALERS for

CELESTRON

14", 8", 5", C90 on display

3500 BATHURST STREET
TORONTO, ONTARIO, M6A 2C6
(416) 787-4584

FREE EDMUND CATALOGUE and BROCHURE(S). PLEASE ASK

YOU CANNOT AFFORD TO BUY A CELESTRON

Without Calling Us For The Most Competitive Prices To Be Found Anywhere

SPECIAL THIS MONTH: SAVE$$

CELESTRON 8

Special coatings, wedge, and tripod

CELESTRON 90

Astro telescope with Celestron wedge and solar filter.

CELESTRON 90

C90 on Meade equatorial mount, 18mm ocular, Barlow lens, diagonal. $375

μTRACT.M.

Available Soon — A New Standard in Drive Correctors

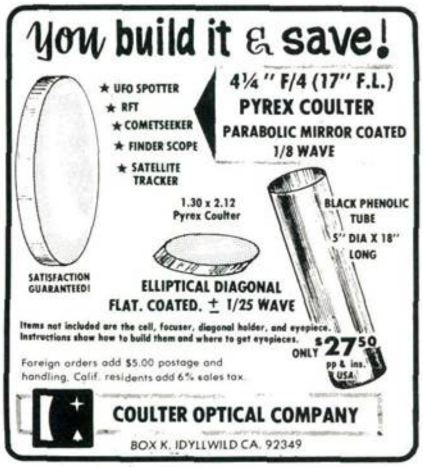
Free shipping in Continental U.S.A. California residents please add sales tax.

96 pages of catalogs and manuals-$2, refundable with first order. Free price list on request.

Demonstrations by appointment, or call to discuss your specific needs.

OPTRON SYSTEMS

EUEGENE L. CISNEROS
15840 East Alta Vista Way Dept. AM
San Jose, California 95127
U.S.A. Phone: 408-259-4394



You build it & save!

★ UFO SPOTTER
★ RFT
★ COMETSEEKER
★ FINDER SCOPE
★ SATELLITE TRACKER

4¼" F/4 (17" F.L.)
PYREX COULTER
PARABOLIC MIRROR COATED
1/8 WAVE

1.30 x 2.12 Pyrex Coulter

BLACK PHENOLIC TUBE
5" DIA X 18" LONG

SATISFACTION GUARANTEED!

ELLIPTICAL DIAGONAL
FLAT. COATED. ± 1/25 WAVE

Items not included are the cell, focuser, diagonal holder, and eyepiece. Instructions show how to build them and where to get eyepieces.

ONLY $27.50 pp & ins. USA

Foreign orders add $5.00 postage and handling. Calif. residents add 6% sales tax.

COULTER OPTICAL COMPANY
BOX K. IDYLLWILD CA. 92349

BOOKS

Deep Sky Objects, A Photographic Guide, Newton, $9.50; hardbound, $12.50	
Introduction to Photographic Principles, Larmore	$2.50
Outer Space Photography, Paul	$9.95
Photoguide to Filters, Reynolds	$6.95
Sky Shooting: Photography, Mayall and Mayall	$3.50
Accu-Star	$11.95
Atlas Australis	$22.50
Atlas Borealis	$22.50
Atlas Eclipticalis	$27.50
Atlas of the Heavens, Becvar, Deluxe, $14.50; Field, $5.00; Desk, $5.00; Catalogue,	$10.50
Celestial Objects for Common Telescopes, 2 Vols., Webb	$6.00
Galaxies, Shapley, $14.00; softbound	$5.95
How To Read The Night Sky, Kals	$5.95
Hubble Atlas of Galaxies	$16.00
Naked-Eye Astronomy, Moore	$8.95
New Guide to the Planets, Moore	$7.95
New Guide to the Stars, Moore	$9.95
Photographic Atlas of the Moon, Kopal	$30.75
Revised New General Catalogue	$10.50
Astronomical Dictionary in Six Languages: English, Russian, German, French, Italian, Czech	$55.00
Astronomy Made Simple, Degani	$2.50
Black Holes in Space, Moore & Nicolson	$7.95
History of Astronomy From Thales to Kepler, Dreyer	$4.50

For more books, sidereal rate generator, drive correctors and mirror kits send 35¢ in STAMPS for our illustrated catalog.

WILLMANN-BELL INC.
P. O. Box 3125, Richmond, Va. 23235
Telephone: 804 - 320-7016

*********** **WANTED** ***********

Current addresses from approximately 1,000 Celestron telescope owners who have moved since the last updating of our mailing list 12 months ago.

Please let us know your current whereabouts so we can continue sending tech bulletins, new product announcements and other data that will help you use your Celestron most effectively.

ALSO WANTED

Addresses from the many Celestron owners who have acquired their instruments second-hand, so that we may extend the same services to you.

Reply to

CELESTRON INTERNATIONAL

2835 Columbia Street, Dept. MLX
Torrance, California 90503

FOR SALE — 8" Newtonian, hand ground 1/4 wave; equatorial mount; clock drive; machined parts; fiberglass tube, spider mount; orthoscopic eyepieces (4mm, 9mm, 25mm); $250.00. Contact Richard Bise, 778 Scott Pl., Apt. 33, Costa Mesa, CA 92627. Phone (714) 759-5632 days, or 631-5087 evenings.

FOR SALE — 2.4" refractor with equatorial mount, tripod, 3 eyepieces, Barlow, erector. Best offer over $75.00. Write Jack Blackmun, 14081 Rondeau-Apt. #7, Westmenster, CA 92683.

FOR SALE — Edmund 6" reflector, equatorial mount, pedestal base, R.A. and declination circles, 6x finderscope, 4 eyepieces, accessory case. Excellent condition. Price: $250.00. Contact Tony DiSciullo, 741 Windsor Circle, Folcroft, PA 19032. Phone (215) 586-6620.

FOR SALE — Celestron 8, special coatings, wedge; 2 years old; $750.00. Coulter 10" f/8 mirror, never used; 10" flotation type mirror mount, spider; $130.00. Will consider trade. Contact Mason Deen, 301 2nd St., Schertz, TX 78154. Phone (512) 658-3709.

FOR SALE — Celestron 8, new model. Complete accessories, Astro-Physics dual axis inverter, declination motor, 8 x 50 finder, Vernonscope oculars, wedge. Price: $1,650.00 firm, f.o.b. Write Carl V. Robertson, 4299 Trout Dr., S.E., St. Petersburg, FL 33705.

FOR SALE — ASTRONOMY back issues: January 1975 through December 1976. $60.00 for set, or $3.50 each. Also miscellaneous NASA documents on SETI; $15.00. Write Mike Ross, 714 Union Ave., Romeoville, IL 60441.

FOR SALE — 2 12-1/2" telescopes (tube assemblies only): f/4.6 Newtonian and f/15 Cassegrain; both 1/16 wave. Excellent performers; mint condition. Best offer, or will trade one for 20" mirror blank. Contact August Schug, 4526 Vicksburg, Sylvania, OH 43560. Phone (419) 882-1592.

POTTER SALES & SERVICE

Celestron, *UNITRON*, STAR INSTRUMENTS, **VERNONscope**, **UNIVERSITY OPTICS**, DayStar Filters, DOAA, ASTROPHYSICS, CROSS OPTICS

Demonstrations by appointment

723 CEDAR, DEPT. AM,
SANDWICH, IL 60548
815-786-8168

master charge

FOR YOUR ASTRONOMICAL NEEDS

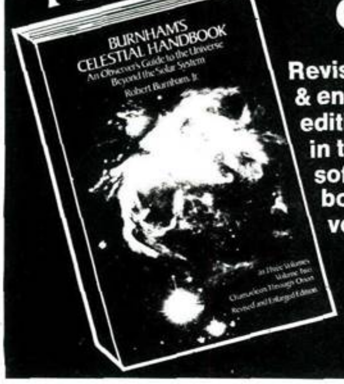
MMI CORPORATION
ASTRONOMY MATERIALS
EDUCATIONAL MATERIALS FOR ASTRONOMY PHYSICS
PHYSICAL SCIENCE EARTH SCIENCE SPACE SCIENCE

ASTRONOMY MATERIALS

Just released! New 1978 MMI Astronomy Materials Catalog. A wealth of new items and slide sets. Send $1.00 for catalog 178. BONUS: Sample color slide.

Close Encounters of the 3rd Kind - 20 slide set with cassette narrated by Dr. J. Allen Hynek, Center for UFO Studies. Selected from 1000's of cases. Slides w/cassette $14.95 ppd.

16" dia. Lunar Globe on free base $59.95 FOB
16" dia. Mars Globe on free base $89.75 FOB
Add 10% overage, promptly refunded.
Under $15.00, add $1.00 service chg.
VISA/ MC accepted. **MMI CORPORATION**
Dept. A, 3016 Cresmont Ave.
Baltimore, Md. 21211 (301) 366-1222


New!
BURNHAM'S CELESTIAL HANDBOOK
An Observer's Guide to the Universe Beyond the Solar System
Robert Burnham, Jr.
In Three Volumes
Volume Two
Chamaeleon Through Orion
Revised and Enlarged Edition

BURNHAM'S CELESTIAL HANDBOOK

Revised & enlarged edition in three soft bound volumes

NOW AVAILABLE Volume 1 & Volume 2 (665 pp ea) @ $8.50 ea + 50¢ postage.
AVAILABLE FALL 1978 Volume 3 which covers section 6 to 8 of the previous edition.
RESERVE YOUR COPY NOW @ $8.50 ea + 50¢ postage.
Write for NEW FREE LIST of astronomical literature & star atlases.

Herbert A. Luft
Scientific & Technical Books
P.O. Box 91, Oakland Gardens, N.Y. 11364

ANNOUNCING ANOTHER AMATEUR ASTRONOMER INC. GALA TELESCOPE CLINIC, WORKSHOP and STAR PARTY at UNION COLLEGE SPERRY OBSERVATORY, Cranford, NJ
Saturday, June 3, 1978 10 am till 12 pm

Instruction in Telescope use and selection.

Lectures on Telescope adjustment and Astrophotography. Optical goods Flea Market. Observatory 10" Refractor and 24" Reflector in operation.

Food available. Celestron 90 Spotter scope door prize. Mail $10 registration fee to: **Roger W. Tuthill**
11 Tanglewood Lane Dept. AM,
Mountainside, NJ 07092

FOR SALE — ASTRONOMY back issues: July 1974; May, August, October 1975; March through December 1976; January, April, May, July, September through December 1977. Send offer to John M. Leopold, 29 N. Country Club Rd., Decatur, IL 62521.

FOR SALE — Tasco 3" f/15 equatorial refractor. Many extras. Price: $275.00. Contact Brian Rasnow, 1000 S. Ventu Rd., Newbury Park, CA 91320. Phone (805) 498-3312.

CELESTRON TELESCOPES
IN STOCK FOR FAST
DELIVERY
J & R OPTICS
2829 LAKEWOOD DRIVE
COLUMBUS, OHIO 43229
WRITE FOR PRICE LIST
AND YOUR SPECIFIC NEEDS

ASTRO-FILMS
35mm, 36-exp. rolls
•Kodak Spectroscopic with antihalation rem-jet backing
Choose 103aF, 103aE, or 103aO $6.19 ea
3 or more $5.39 ea. 5 or more $4.59 ea.
•SO-115 (planets, moon, sun) $2.10 ea.
•High Contrast Copy (planets, moon, sun) $2.10 ea.
•2475 ASA 1000-4000 $2.65 ea.
Film information 35¢, free with order.
ASTROFILM
P.O. Box 2731, Dept. AM Akron, OH 44301

CELESTRON TELESCOPES
ON DISPLAY AND IN STOCK
E & W OPTICAL, INC.
2420 EAST HENNEPIN AVE.
DEPT. AM
MINNEAPOLIS, MINN. 55413
612-331-1187
SEND FOR PRICE LIST "A"—
Astronomy supplies and accessories

NEW
CYCLOPS 2.5
Deep-Space Lens System
Special Introductory Price Ends June 1

The Cyclops 2.5 is a wide-angle, high speed lens system whose performance rivals that of the 5-1/2" Schmidt camera but at less than 1/3 the cost. The Cyclops system allows you to connect your 35mm camera and T-ring directly to the T-thread focuser without need for film holders.

CYCLOPS 2.5 SPECIFICATIONS
Aperture — 3"
Speed — f/2.5 to f/16 (adjustable iris)
Focal length — 7" Weight — 5 lbs.
Lens housing — Machined aluminum
Color — Orange & Black
Price — $249.95

LAST MONTH AT SPECIAL INTRODUCTORY PRICE: $195.00 Complete, ready for your camera.

Astroscan rubber combat jacket $29.95
C8 Rubber/nylon dewcaps $19.95
C90 Dewcaps $10.00
C8 Full-range latitude adjuster $25.00
C8/C14 Coupler mounting bracket $25.00
C90 1-1/4" eyepiece diagonal adapter $25.00
C8/C14 Tangent coupler, 15" swing, micro-adjusting $80.00
C14 Full-range latitude adjuster $49.95
C14 Anti-swing weight $27.00
C14 Wheels $89.95

Kang-A-Pouch pockets for three 2" and four 1-1/4" oculars. $6.95. 2" oculars, 30mm, 40mm, 50mm, 60mm, and 70mm. Plossls 100% American Made — The finest we've seen. $125.00. Astroscan finder/sight. Bazooka ring sight mounts easily, no holes to drill. $17.95

NEW
"Pac-A-Pod" padded vinyl Celestron tripod carrying case. $24.95 (Black)

NEW
"Wedgee Bag" padded vinyl Celestron wedge carrying bag. $15.00 (Black)

CALL US LAST!
We'll beat any Celestron dealer's best price plus include a free full-range heavy-duty latitude adjuster and deliver immediately from stock!

COMING SOON "Roland Mk.5"

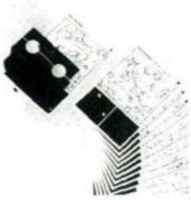
Stocking dealers for Celestron, Meade, Edmund, Unitron, DayStar, Astro-Physics, DOAA, VERNONscope, Gieseler, University Optics, Bushnell, Bausch & Lomb Microscopes, Sony TV, RCA, Sky Publishing and Gall Publications. Jet lathes, mills, drill presses, fine tools, and more.

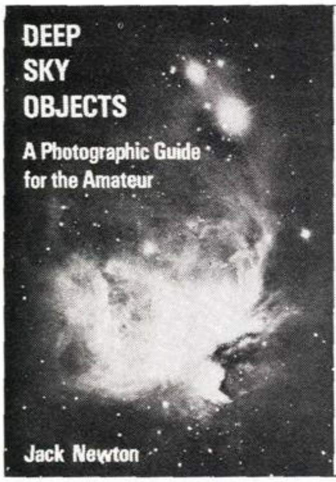
FREE SHIPPING ON MOST ITEMS IN THE U.S.A. We honor Master Charge & Visa
Qualified personnel to answer your questions. Satisfaction guaranteed or money refunded.
B. E. MEYERS & CO. 2717 200th Ave. S.E., Issaquah, Wash. 98027 Telephone 206-392-2237

DEEP SPACE 3-D
A Stereo Atlas of the Stars

Have you ever wished you could see the familiar constellations in 3-D? **DEEP SPACE 3-D** adds depth to the sky, giving it a vivid texture our eyes alone fail to perceive. The entire sky is covered on 14 5" by 8" cards, each having a pair of computer-generated views and a reference chart. A folding desk-top stereo viewer with glass lenses is included.
$6.95 ppd. California residents add 6% sales tax. Foreign orders, add $1.00.

David Chandler
Dept. AM, P.O. Box 309
LaVerne, Calif. 91750
Phone: 415/327-2668




DEEP
SKY
OBJECTS
A Photographic Guide for the Amateur
Jack Newton

DEEP SKY OBJECTS
A Photographic Guide for the Amateur

This guide will help you to locate and identify more than 125 galaxies, nebulae and star clusters, including the complete Messier catalog.

The 75 full-page photographs are all taken with a 12.5 inch telescope to the same one-degree scale. Easily compare the size, shape and brightness of each object illustrated.

Over 50 two-color detailed finder charts quickly indicate when and where you can see these fabulous sights.
Send $9.50 ($12.50 deluxe) to
GALL Publications
1293 Gerrard St., E., Toronto, Canada

SHELDON FAWORSKI
Dealer for:
CELESTRON
Meade Instruments,
Star Instruments,
Unitron,
VERNONscope,
Giesler "Accutrack",
and
Astro-Physics.
CELESTRON OWNERS
send for BULLETIN C.
9940 La Reina Ct. Dept. A
Orland Park, Ill. 60462
(312) 349-2339

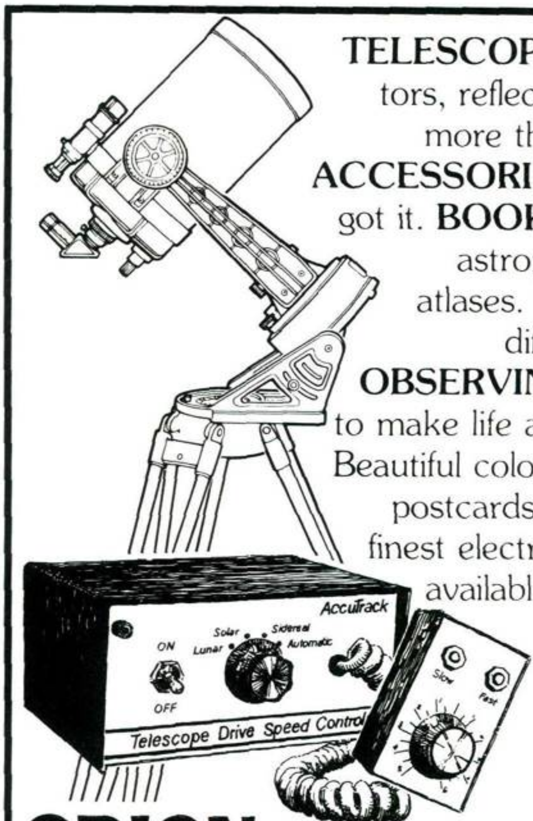
"Priceless . . ."
'Your Astronomy courses are excellent. Never have I undertaken any educational course where the school was more interested in actually wanting its students to LEARN what was taught, rather than issue a passing grade. What I have learned is priceless. Many thanks.''
Jack D. Ellis, Oklahoma City, Oklahoma

Coast Navigation School specializes in individual instruction. Call or write today for our free course catalog describing our streamlined home study courses designed especially for amateur astronomers.

CELESTRON Schmidt-Cassegrain and UNITRON refractor telescopes available.
Special prices on course/telescope combinations.

Coast Navigation School of Astronomy
Dept. 5368, 22 North Milpas
Santa Barbara, CA 93102/(805) 963-7837

I'm interested! Please send me your free school catalog.
Name
Address
City
State, Zip



TELESCOPES: Celestrons, refractors, reflectors, spotting scopes— more than 16 different models. **ACCESSORIES:** You name it, we've got it. **BOOKS:** A huge selection of astronomical books and star atlases. **EYEPIECES:** Over 50 different oculars in stock. **OBSERVING AIDS:** Many items to make life a lot easier. **VISUALS:** Beautiful color slides, prints, posters, postcards. **ACCUTRACK:** The finest electronic telescope controls available. **EXPERT ADVICE:** Give us a call anytime. **LOW PRICES:** Need we say more? **FREE CATALOG.**

VISA master charge

ORION Telescope Center

A Division of
Gieseler Electronics

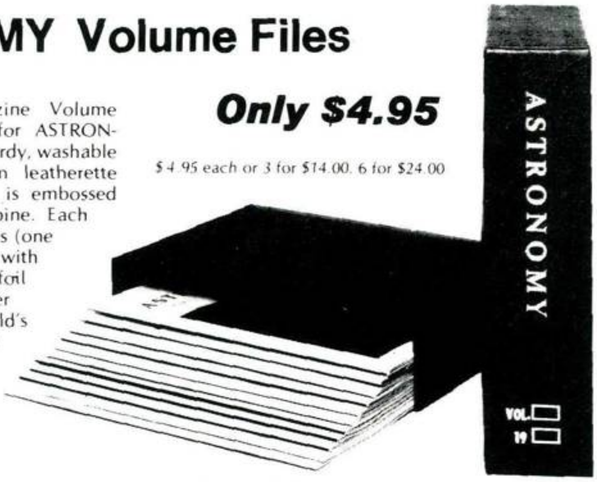
303 Potrero #6-C, Santa Cruz, CA 95060 (408) 425-1720

ASTRONOMY Volume Files

Custom designed magazine Volume Files are now available for ASTRONOMY subscribers. These sturdy, washable cases have a rich brown leatherette finish, and ASTRONOMY is embossed in elegant gold on the spine. Each case holds 12 80-page issues (one complete year), and comes with a slip of gold signature foil to fill in volume number and year. Keep the World's Most Beautiful Astronomy Magazine beautiful year after year with this impressive addition to your library.

Only $4.95

$4.95 each or 3 for $14.00. 6 for $24.00



To order, simply fill in and mail the attached coupon today!

Use this address **ONLY** for Volume File orders and correspondence regarding them.

ASTRONOMY Volume Files
P.O. Box 5120
Philadelphia, PA 19141

Enclosed is $________ in payment for the following ASTRONOMY Volume Files:

________ **1 for $4.95** ________ **3 for $14.00** ________ **6 for $24.00**

Name ________________

Address ________________

City ________ **State** ________ **Zip** ________

U.S.A. orders only. Allow 3 weeks for delivery.
Full money back guarantee.

FOR SALE — Refractor telescope. 60mm objective lens, 900mm focal length; tripod; equatorial mount; many extras. All in excellent condition. Best offer over $100.00. Write Nick Strish, 8673 S.W. 137th Ave., Miami, FL 33183.

FOR SALE — 7 x 35 Jason binocular case and caps, $33.00. Meade star diagonal, $8.00. 1-1/4" eyepieces (12.7mm, 9mm, 7mm A.R. Criterion, 6mm), $6.00 each. Contact Mark Gibson, 3029 Herbert St., Norfolk, VA 23513. Phone (814) 855-5736.

FOR SALE OR TRADE — Criterion Dynamax 8" telescope with sturdy steel tripod (valued at $189.00), complete accessories. Price: $700.00, negotiable. Will consider trade for Celestron 3". Contact Scott Rauland, Box 1019, Earlham College, Richmond, IN 47374. Phone (317) 962-6561, ext. 253.

WANTED — 4mm and 6mm 1-1/4" O.D. orthoscopic eyepieces. Must be in excellent condition and reasonably priced. Please state brand, price. Write Gail O. Clark, 74 Mountain Dr., Pocatello, ID 83201.

WANTED — Back issues of ASTRONOMY: Vol. 3, No. 8 (August 1974) through Vol. 4, No. 4 (April 1975) inclusive. Must be in good condition; will pay $3.00 each. Write John Frenzel, 1828 Trowbridge Cove, Dunwoody, GA 30338.

WANTED — Smithsonian Star Atlas and/or Catalog; "The Story of Comets" by George F. Chambers; "Canon of Eclipses" by Jan Meeus. Please send price, condition to Richard A. Keen, 519 University Ave., Boulder, CO 80302.

WANTED — Plans for building observatory for 6" Edmund reflector. Plans for equatorial mount for 10" or larger reflector, clock drive, R.A. and declination, polar axis. Write Jerry Lea, Box 598, Sterling, AK 99672.

WANTED — Correspondence with anyone interested in science fiction, science fiction conventions, astronomy, art. Write Linda Leach, 19132 Appleton, Apt. C-218, Detroit, MI 48219.

WANTED — Contact with "Lost in Space" fans to share material. No "trekkies!" Serious inquiries only. Write Jon Gibbs, R.D. #2, Box 368, Branchville, NJ 07826, or James McGown, 948 Marland Dr. S., Columbus, OH 43224.

WANTED — Slides of special effects from "Close Encounters of the Third Kind", "Starship Invasions", "Quark" for comparison. Will pay. Write Jim Martin, 2300 Windsor Rd., Alexandria, VA 22307.

WANTED — October 1973 issue of ASTRONOMY to complete collection. Must be in fairly good shape; will pay $10.00. Write Charles J. Portocales, 23 1/2 N. Walnut St., West Chester, PA 19380.

WANTED — "Variable Star Observer's Handbook" (1971) by John Glasby. Write Chris E. Spratt, 1431 St. Patrick St., Victoria, British Columbia, CANADA V8S 4Y5.

INFORMATION WANTED — For article research: what astronomy (science) means to you; why study astronomy; favorite branch, astronomer (why); search/discovery for life: benefits, consequences, aid to world co-existence; promise of space exploration for man. Age, sex. Write Larry Giannou, 3522 E. 32nd St., Spokane, WA 99203.

ANNOUNCEMENT — The Fremont Astronomical Society meets every 3rd Saturday of the month at 7 p.m. Persons interested in astronomy are welcome. For information, contact Mark A. Hall, President, Fremont Astronomical Society, 1065 Millbrook Dr., Fremont, OH 43420. Phone (419) 332-0886.

ANNOUNCEMENT — The Jackson Astronomical Association invites all central Mississippi astronomers to join us. For information on activities or membership, call Ben White, President at (601) 373-3904, or Jimmy Duke, Vice President at (601) 924-4162.

Positions Available with ASTRONOMY Magazine

ASTRONOMY is seeking to enlarge its Milwaukee editorial staff. The positions to be filled are for content writers/editors, which require combined ability to write and knowledge of astronomy as outlined below.

Knowledge of Astronomy

To qualify for current editorial openings, applicants must be knowledgeable in one or both of the following areas:

A. Knowledge and experience with practical astronomy including the full gamut of amateur observing, use of telescopes and other astronomical equipment, possibly equipment, building, astrophotography — all activities of interest to the practicing astronomy enthusiast.

B. Well-versed knowledge of education in descriptive astronomy, current astronomical research and space science, thorough comprehension of the physical appearance, behavior and nature of mathematical or theoretical concepts such as black holes, quasars, stellar evolution, etc.

Ability to Write

Applicants must be able to communicate extremely well as writers; demonstrated ability to write clearly with fresh, lively style a definite must. Ability to make technical information understandable to a broad audience of people who are newly introduced to astronomy, or who have very limited knowledge of equipment and observing techniques an absolute necessity. Along with knowledge of astronomy, at least one of the following criteria must be met.

A. Journalism, communication or English education, courses or degree emphasizing magazine writing, editing, layout and design.
B. Experience as a writer/editor for major media.
C. Proven experience/ability as a writer.

Positions will be filled when the appropriate individuals are found. Competitive salary offers will be tailored to the individuals' knowledge, ability and experience. Employment will require relocating in Milwaukee or surrounding suburbs.

Full benefit program includes major medical, hospitalization, dental and life insurance, sick days, two weeks paid vacation after one year.

Send brief letter addressing yourself to your knowledge of astronomy and ability to write. We will recontact you with our application form, questionnaire and test assignments.

Personnel Department
ASTRONOMY
411 E. Mason St., 6th Floor
Milwaukee, WI 53202
(414) 276-2689

Meteorites
Cold Cameras
Quasars
Phobos
Astrophotography
Supernova
Milky Way
MARS
Skylab
HEAO
AURORAE
Sunspots
Novae
Light Pollution
Galaxies
Asteroids
Saturn
Redshift
Perseid Meteors

ASTRONOMY
Index to Volume 5, 1977

ASTRONOMY's cumulative subject Index to Volume 5, 1977 is now available. Covering the months of January through December 1977 (issue Nos. 1 through 12), it will be a valuable addition to your home library. Index to Volume 5 is available for $1.25** each.

Indexes to Volumes 1 through 4 are still available for only $1.00** each.

** Be sure to enclose an additional 25¢ per order for postage and handling.

Order your indexes today!

ASTRONOMY
411 E. Mason St.-6th Floor
Milwaukee, WI 53202

22½"
22½"
SLITFRAME
60¼"
67¼"
SPRING LINE
140¼"
DOME SKIRT
SHUTTERS OPEN
30"
76¼"
115"
SIDE VIEW WITH OPTIONAL BASE
SHUTTERS CLOSED

A NEW STAR.
Observa-DOME Silver Series.

Observa-DOME, the world's most experienced manufacturer of Observatory Systems, has developed its new SILVER SERIES utilizing skills and techniques gained from 25 years of building more professional observatory structures than anyone else!

The affordable SILVER SERIES incorporates all the "most wanted" features which astronomers, both amateur and professional, have demanded! Overwhelming acceptance of our Two-Meter Silver Series Observa-DOME has led to our latest Three-Meter design with other larger Silver Series Observa-DOMES to come.

"Do-it-yourself" Components

For the very first time "difficult to fabricate" components of the Observa-DOME Silver Series Two and Three-Meter Models are available for those willing to make their subassemblies according to our detailed drawings, instructions and material lists. This new program is designed to make your individual or group observatory project a complete success.

Exclusive sales agency in USA & Canada for the incomparable **ZEISS** Planetarium.

Observa-DOME
LABORATORIES, INC.
Phone (601) 982-3333
P.O. Box 885
Jackson, Mississippi 39205

I am interested in information on an Observa-DOME of:
☐ 2 MTR., ☐ 3 MTR., ☐ Complete ☐ Components or
__________ diameter Observa-DOME.

Name __________
Address __________
City ______ State/Prov. ______ Zip ______

NEW: LC-8 CELESTRON Available Only from S&S OPTIKA

From the S & S Optika precision people...a totally new concept in satisfying the needs of the professional and knowledgeable amateur astronomer. We proudly announce a fully proofed laser collimated and certified Celestron 8 telescope! Along with the purchase of package #100 you will receive the fabulous LC-8 telescope with distinctive black band, a ronchigram which is your photographic proof of optical correction and a letter of certification. Furthermore, the telescope is gone through completely for all mechanical adjustments. If you are contemplating the purchase of a Celestron telescope be sure to document the accuracy of your instrument and protect your investment.

Call or write today for further information.

THE 6 METER
K & E MOUNTED
40 CM-CA
LASER COLLIMATOR.

THE LC-8 CELESTRON
TELESCOPE WITH
THE DISTINCTIVE BLACK BAND—
THE MARK OF PROVEN EXCELLENCE!

PACKAGE #100

1.	Celestron LC-8 Telescope	$895
2.	Wedge	45
3.	Micro-Fine Latitude Adjustor	No Charge
4.	Weatherproof Accessory Case	No Charge
5.	*Freight UPS Continental U.S.*	*No Charge*
6.	Certificate for Special Discounts on Selected Accessories	No Charge
	TOTAL	$940

PACKAGE #140

1.	Celestron LC-5 Telescope	$720
2.	Wedge	45
3.	*Micro-Fine Latitude Adjastor*	*No Charge*
4.	Weatherproof Accessory Case	No Charge
5.	Freight UPS Continental U.S.	No Charge
6.	Certificate for Special Discounts on Selected Accessories	No Charge
	TOTAL	$765

INTRODUCING THE INCREDIBLE CELESTRON 90

Contact us at S & S OPTIKA now about this newest of the *Celestron line...*

ACCESSORY TRAY

For Celestron Tripods
- Accessory and Stabilizer Tray
- Freight UPS Continental U.S. No Charge

$20

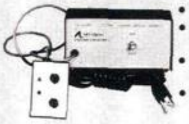
WEATHERPROOF ACCESSORY CASE

- Carries Six Eyepieces, Diagonal, Tele-extender Tele-compressor, Filters, etc. (Not included) $14
- Freight UPS Continental U.S. No Charge

MICRO-FINE LATITUDE ADJUSTER

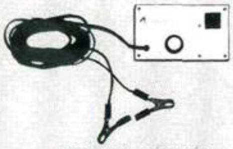
For Celestron Telescopes
- *Full Latitude* Control at Your Fingertips $19
- Freight UPS Continental U.S. No Charge

VARIABLE FREQUENCY DRIVE CORRECTER



- 25-Watt Output
- Solar, Lunar and Sidereal Presets
- Infinitely Adjustable Base Rate
- Instantaneous Add and Subtract Pulse Buttons
- Fully Grounded for Safety
- Includes 20′, 12-Volt Car Cable
- 12-Volt DC or 115-Volt AC Operation
- Freight UPS Continental U.S. No Charge

Coil Cord add $5.00 TOTAL $109



MICRO-GUIDE

- Output Frequency Continuously Variable from 50-70 Cycles
- 6 Watt Grounded Output Can Drive a Celestron *8*
- NASA Spec Circuit Board
- 15′ of Battery Cable
- Freight UPS Continental U.S. No Charge

$29

PACKAGE #10

1.	2″ Unitron Altazimuth Refractor with Micrometer Dial Controls (a perfect starter package)	$190
2.	*Freight UPS Continental U.S.*	*No Charge*
3.	Certificate for Special Discounts on Selected Accessories	No Charge
	TOTAL	$190

PACKAGE #11A

1.	3″ Unitron Folded Optical Path Refractor	$660
2.	1¼″ Eyepiece Adaptor	No Charge
3.	*Freight UPS Continental U.S.*	*No Charge*
4.	Certificate for Special Discounts on Selected Accessories	No Charge
	TOTAL	$660

PACKAGE #7

An extraordinary telescope! 4″ wide-field design.

Our package includes:

Astroscan 2001	$149
Fabulous 24-page Star Atlas	No Charge
Freight UPS Continental U.S.	No Charge
TOTAL	$149

WORLD'S MOST USABLE STAR ATLAS

- *24-Page Full-Color Atlas of the Heavens*
- 11″ x 14″ Plastic Finished Card Stock
- Luminescent Star Finder on Front Cover
- Table of Planetary Locations

$7.75

SEND ME INFORMATION ABOUT:

☐ ______________Telescopes
(Specify Brand)
☐ Variable Frequency Drive Correcters
☐ Weatherproof Accessory Case
☐ Micro-Fine Latitude Adjusters
☐ Your own combination of items
(Specify your needs)

____

____

HERE IS MY ORDER FOR:

☐ Laser certified Celestron LC-8 Pkg. #100
☐ LC-5 Pkg. #140
☐ C-90
☐ Accessory Tray
☐ Accessory Case
☐ Latitude Adjusters
☐ 25 WT VFO
☐ 6 WT Micro-Guide
☐ Unitron 3″ Folded
☐ Unitron 2″ Starter Pkg.
☐ 4″ Astroscan
☐ Star Atlas

Include check, money order or Master Charge Acct. # with your order.

NAME ______________________________

ADDRESS ______________________________

CITY ______________ STATE __________ ZIP ______

TELEPHONE # Area Code (   )

Clip or copy, and mail to:

S&S Optika, Ltd.

Dept. 5A, 3855 S. Broadway, Englewood, CO 80110
Telephone (303) 789-1089

Celestron International

World's Leading Manufacturer of Quality Telescopes

2835 Columbia St. • Torrance, California 90503 • U.S.A. • Telephone (213) 328-9560

CELESTRON AUTHORIZED DEALERS IN THE U.S. AND CANADA

ALASKA

Stewart's Photo Shop
531 W. 4th Ave.
Anchorage, AK 99501

Studio II
145 Brehner
Valdez, AK 99886

ARIZONA

NuArt Photo Service
45 E. Pennington St.
Tucson, AZ 85701

Star Liner Co.
1106 S. Columbus Blvd.
Tucson, AZ 85711

Wilson's Camera Sales
145 W. Adams
Phoenix, AZ 85003

ARKANSAS

Astronomical Unit
6205 Pawnee
N. Little Rock, Ark. 72116

CALIFORNIA

Beach Cities Photo
1822 N. Sepulveda Blvd.
Manhattan Beach, CA 90266

Brooks Camera
45 Kearny St at Maiden Lane
San Francisco, CA 94180

Cal's Camera Inc.
1770 Newport Blvd.
Costa Mesa, CA 92627

Camera Exchange of Beverly Hills
330 N. Beverly Dr.
Beverly Hills, CA 90210

Century Music
448 S. Winchester
San Jose, CA 95128

Century Precision Cine/Optics
10661 Burbank Blvd.
North Hollywood, CA 91601

Daystar Filter Corp.
1513 E. 3rd
Pomona, CA 91769

Don Scott
1614 Tapir Circle
Ventura, CA 93003

Douglas Telescopics
531 State St.
Santa Barbara, CA 93101

Finley's Camera
48 Peninsula Center
Palos Verdes, CA 90274

Frank's Highland Park Camera
5631 N. Figueroa St.
Los Angeles, CA 90042

Henry's Camera
525 W. Eighth St.
Los Angeles, CA 90014

Jacks Camera Exchange
9523 Santa Monica Blvd.
Beverly Hills, CA 90210

Nelson Photo Supplies
1917 India
San Diego CA 92112

Newman's Photo
1150 Hermosa Ave.
Hermosa Beach, CA 90254

Odd Assortment
2057 Salvio St.
Concord, CA 94520

Omni Unlimited
823 Mateo
Los Angeles, CA 90021

Omni Unlimited
105 S. Los Robles
Pasadena, CA 91101

Optech Instruments
266 E. Garvey Ave.
Monterey Park, CA 91754

Optica b/c
4100 MacArthur Blvd.
Oakland, CA 94619

Optron Systems
15840 E. Alta Vista Way
San Jose, CA 95127

Orion Telescope Center
303 Potrero, No. 6
Santa Cruz, CA 95060

Pacific Photo
18120 Brookhurst St.
Fountain Valley, CA 92708

Paul's Photo
23252 S. Hawthorne Blvd.
Torrance, CA 90505

Peninsula Scientific
2185 Park Blvd.
Palo Alto, CA 94306

Photo Imports
8199 Clairemont Mesa Blvd.
San Diego, CA 92111

Photography Unlimited Inc.
16989 Beach Blvd.
Huntington Beach, CA 92647

Refractions-Reflections
600 San Pablo Ave.
Albany, CA 94706

Sight Instruments
2620 E. Pacific Coast Hwy.
Long Beach, CA 90804

Sight Instruments
24570 Hawthorne Blvd.
Torrance, CA 90505

Star Quest Enterprise
378 S. Tustin
Orange, CA 92666

Telescope World
266 Mission Blvd.
Hayward, CA 94544

COLORADO

Denver Museum
City Park
Denver, CO 80205

S & S Optika Ltd.
3853 S. Broadway
Englewood, CO 80110

The Star Tracker
3093 Walnut St.
Boulder, CO 80302

FLORIDA

Abba Equipment
511 Northeast 190th St.
Miami, FL 33179

Aberbach's Photo
441 Arthur Godfrey Rd.
Miami Beach, FL 33140

Atlantic Optics
1302 Niantic Terrace
West Palm Beach, FL 33411

Cole Energy Systems
815 Oranole Rd.
Maitland, FL 32751

Focus Scientific Enterprises
1601 Biscayne Blvd.
Omni International
Miami, FL 33160

Harmon Photo Center
3439 W. University Ave.
Gainesville, FL 32607

GEORGIA

The Rand Corporation
6479 Peachtree Ind. Blvd.
Atlanta, GA 30340

ILLINOIS

American Science Center
5700 Northwest Highway
Chicago, IL 60646

Astro-Physics
2703 Hampden Ct.
Rockford, IL 61107

Helix Camera
325 W. Huron St.
Chicago, IL 60610

Marshall Field & Co.
111 North State St.
Chicago, IL 60690

Model Camera
1342 East 55th St.
Chicago, IL 60615

Potter Sales & Service
723 Cedar
Sandwich, IL 60548

INDIANA

Lawndale Camera Shop
817 So. Greenriver Rd.
Evansville, IN 47715

IOWA

Jones Camera Supply
1200 East Platt
Maquoketa, IA 52060

KANSAS

Hutchinson Planetarium
1300 N. Plum
Hutchinson, KS 67501

Perpro
8365 Farley
Overland Park, KS 66212

Wolfe's Camera Shop
635 Kansas Ave.
Topeka, KS 66603

LOUISIANA

The Camera Shop
812 Metairie Rd.
Metairie, LA 70005

The Camera Shop
7505 Maple St.
New Orleans, LA 70118

MARYLAND

Perma Tone
8638 Loch Raven Blvd.
Towson, MD 21204

Towson Photo Supply
401 Washington Ave.
Towson, MD 21204

MASSACHUSETTS

Astronomics
227 Linwood St.
Lynn, MA 01905

Interstellar Enterprises
201 North Mill Street
Holliston, MA 01746

MICHIGAN

Feldman Camera Exchange
300 Oak St.
Wyandotte, MI 48192

Precision Telescope Center
58080 Jewell Road
Washington Twp., MI 48094

University Optics
2122 E. Delhi Rd.
Ann Arbor, MI 48106

MINNESOTA

Duluth Camera Exchange
321 West Superior St.
Duluth, MN 55802

E & W Optical
2420 E. Hennepin Ave.
Minneapolis, MN 55413

Virginia Boat & Sporting Dist.
205 5th Ave., So.
Virginia, MN 55792

MONTANA

AMC Sullivan Photo
107 East Main
Bozeman, MT 59715

NEVADA

Hobby House
2009-11 East Charleston Blvd.
Las Vegas, NV 89104

Univ. of Nevada/Reno
Planetarium Gift Shop
Reno, NV 89557

2001 Odyssey Shop
MGM Grand Hotel
3645 Las Vegas Blvd., So.
Las Vegas, NV 89109

NEW JERSEY

Dover Photo Supply
25 E. Blackwell St.
Dover, NJ 07801

Ridgewood Camera
48 E. Ridgewood Ave.
Ridgewood, NJ 07450

Tuthill, Roger
11 Tanglewood Lane
Mountainside, NJ 07092

NEW YORK

47th Street Photo, Inc.
36 E. 19th St.
New York, NY 10003

Hirsch, Edwin
Lake View Dr.
Tomkins Cove, NY 10986

Johnson's Studio & Camera
3208 Erie Blvd.
De Witt, NY 13214

Main Camera Center
66 Franklin St.
Rochester, NY 14604

Stangert Corp.
94 Long Beach Rd.
Island Park, L.I., NY 11558

Vernonscope
5 Ithaca Rd.
Candor, NY 13743

OHIO

Center of Science & Industry
280 E. Broad St.
Columbus, OH 43215

Dodd's Camera
7795 W. Ridgewood Dr.
Parma, OH 44129

OREGON

Conkling, Inc.
4929 N. E. Fremont
Portland, OR 97213

Oregon Museum of Science
& Industry
4015 S.W. Canyon Rd.
Portland, OR 97221

PENNSYLVANIA

Astro-Marts
4801 McKnight Rd.
Pittsburgh, PA 15237

(The) Camera Shop
1420 11th Ave.
Altoona, PA 16601

Carman's
4209 Edgemont Ave.
Brookhaven, PA 19015

Esman's Good Luck Dist.
560 Broadway
Pitcairn, PA 15140

Mid City Camera Exchange
1316 Walnut St.
Philadelphia, PA 19107

Uptown Sales, Inc.
33 N. Main St.
Chambersburg, PA 17201

TENNESSEE

Cygnus Instruments
211 37th Ave., N. #4
Nashville, TN 37209

Electronics Ltd.
2816 White Oak Drive
Nashville, TN 37215

TEXAS

Bill Weaver Sporting Goods
3515 W. Vickery
Fort Worth, TX 76107

Burke Baker Planetarium
5800 Carolyn St.
Hermann Park
Houston, TX 77004

Don Casey Co.
229 Garvon
Garland, TX 75040

Hidalgo Supply
11246 S. Post Oak Rd.
Suite 308
Houston, TX 77035

Houston Jewelry & Dist. Co.
9633 Westheimer
Houston, TX 77042

Keaton Kolor
3520 N. 6th St.
Abilene, TX 79603

Pampa Photo
1820 N. Hobart
Pampa, TX 79065

Sigma Engineering Co., Inc.
Box 5285 (Airport Ind. Area)
Lubbock, TX 79417

Studer's Photo
146 Stribling
San Antonio, TX 78292

Texas Camera
5307 Airport Blvd.
Austin, TX 78765

Texas Nautical
3209 Milam St.
Houston, TX 77006

Total Camera
6128 Westheimer
Houston, TX 77057

UTAH

Allen's Camera
36 N. University
Provo, UT 84601

Hammond Hobby
4835 Highland Drive
Lower Cottonwood Mall
Salt Lake City, UT 84117

Hammond Tots & Toys
1102 Fort Union Blvd.
Family Center
Murray, UT 84117

Hansen Planetarium
15 S. State St.
Salt Lake City, UT 84111

VIRGINIA

Dumaurier Co., Inc.
3400 Atlantic Avenue
Virginia Beach, VA 23451

Dumaurier Co., Inc.
Hilltop Sq., 550 First
Colonial Rd., Suite 309
Virginia Beach, VA 23451

WASHINGTON

B. E. Meyers & Co.
2717 200th Ave. S.E.
Issaquah, WA 98027

(The) Camera Shop
1003 Pacific Ave.
Tacoma, WA 98402

Clyed's Camera
1410 4th Ave.
Seattle, WA 98101

The Crescent
710 West Riverside
Spokane, WA 99201

Tobey's Photofinishing
1304 Cornwall
Bellingham, WA 98225

WISCONSIN

(The) Camera Center
1700 E. Capitol Dr.
Milwaukee, WI 53211

Wack Electronics
5722 West North Ave.
Milwaukee, WI 53208

CANADA

Brooks Supplies Ltd.
1031 Robson St.
Vancouver, B. C.
Canada V6E 1A9

Centennial Planetarium
P.O. Box 2100
Calgary, Alberta,
Canada T2P 2M5

Edmund Scientific Products
3500 Bathurst St.
Toronto, Ontario
Canada M6C 2C6

Focus Scientific
160 Elgin St.
Place Bell, Ottawa
Ontario, Canada K2P 2C4

Focus Scientific
186 Queen St. West
Toronto, Ontario
Canada M5V 1Z1

Jovian Scientific
1119 Tower Rd. 603
Halifax, Nova Scotia
Canada B3H 4H5

Lewis Instruments Ltd.
1438 Erin St.
Winnipeg, Manitoba
Canada R3E 2S8

Manitoba Museum of Man
& Nature
190 Rupert Ave.
Winnipeg, Manitoba
Canada R3B 0N2

Museum Planetarium Shop
1100 Chestnut St.
Vancouver, B.C.
Canada V6J 3J9

Queen Elizabeth Planetarium
Coronation Park
Edmonton, Alberta
Canada T5J 0K1

Tele-Optics
2026 8th Ave., S.E.
Calgary, Alberta
Canada T2G 0N8

NEW DEALER INQUIRIES INVITED

3/10/78

STAR DOME

JUNE

by
James Mullaney and Henry J. Phillips

Included in this month's Close-up region is Libra the scales — perhaps the constellation of the zodiac with the least "personality". Several of the zodiacal constellations — including Taurus, Gemini, Leo, Scorpius and Sagittarius — contain bright stars and have easily remembered patterns. Others, like Cancer, Virgo, Aquarius and Pisces, don't have as many bright stars but have at least one distinguishing feature — be it a famous star cluster or a recognizable asterism. But Libra doesn't seem to have anything; its stars are neither particularly bright nor distinctively arranged, and if it were not in the zodiac, it would undoubtedly be a lot less well-known than it is.

Part of Libra's problem may be that, of all the zodiacal star groups, it alone represents an inanimate object — a pair of scales. The other 11 constellations stand for people or animals rich in mythological lore. When was the last time you read a myth about a pair of scales? We could try making up our own stories, of course ("One day, the goddess Aphrodite, after an orgy of chocolate-covered caramels, stepped on her bathroom scales and discovered to her chagrin that...."). But the only existing mythological significance Libra has is that it stands for the scales of Astraea, goddess of justice, represented in neighboring Virgo.

Libra is not alone among constellations in suffering this paucity of legend; most of the star groups that signify inanimate objects also draw a blank as far as mythology is concerned. It may surprise readers, therefore, to learn that these same inanimate items outnumber every other category of object depicted in today's 88 constellations. Among all the recognized star groups, we find 15 that represent people, 18 land animals, nine birds, eight water animals, four reptiles, three invertebrates and two "landscapes" — but a total of 29 nonliving things!

A lot of variety exists in the sky, not only *in toto*, but also within each of these subdivisions. For example, our 15 "people" constellations include seven — Andromeda, Cassiopeia, Cepheus, Gemini, Hercules, Orion and Perseus — that bear the names of characters from classical Greek and Roman mythology. Six of the others (Aquarius, Auriga, Bootes, Ophiuchus, Sagittarius and Virgo) are less easily identified with specific personages, but may represent certain occupations that were important to their inventors — water carrier, shepherd, archer, medicine man, etc. Four of these groups — Gemini, Virgo, Sagittarius and Aquarius — are in the zodiac. The remaining two star groups in this category include Centaurus the centaur (a mythical being — see last month's Star Dome), and Indus the Indian, a group introduced by Johann Bayer in 1603 and therefore not one of the classic groups.

Of the 18 constellations that signify land animals, 12 date from antiquity, including several from the zodiac: Aries the ram, Taurus the bull, Leo the lion, and Capricornus the goat. Also among this group are two bears and two dogs — Ursa Major and Minor, and Canis Major and Minor — as well as two horses, Pegasus and Equuleus (although Pegasus has the additional distinction of bearing wings; he is, in fact, another character from Greek mythology). Lepus and Lupus, the hare and the wolf, complete this list of 12. The other six (Camelopardalis, Canes Venatici, Leo Minor, Lynx, Monoceros and Vulpecula) are 17th century additions.

Our nine birds include only three classic star groups: Aquila the eagle, Corvus the crow, and Cygnus the swan. All the rest are located in the southern sky, where they were placed by 17th century cartographers. These include Apus, Columba, Grus, Pavo, Phoenix and Tucana.

The eight water animals include two mammals (Cetus the whale and Delphinus the dolphin), two sea serpents (Hydra and Hydrus) and four fishes (Pisces the fishes, a zodiacal group, Piscis Austrinus the southern fish, Dorado the goldfish, and Volans the flying fish). All but Hydrus, Dorado and Volans date from antiquity.

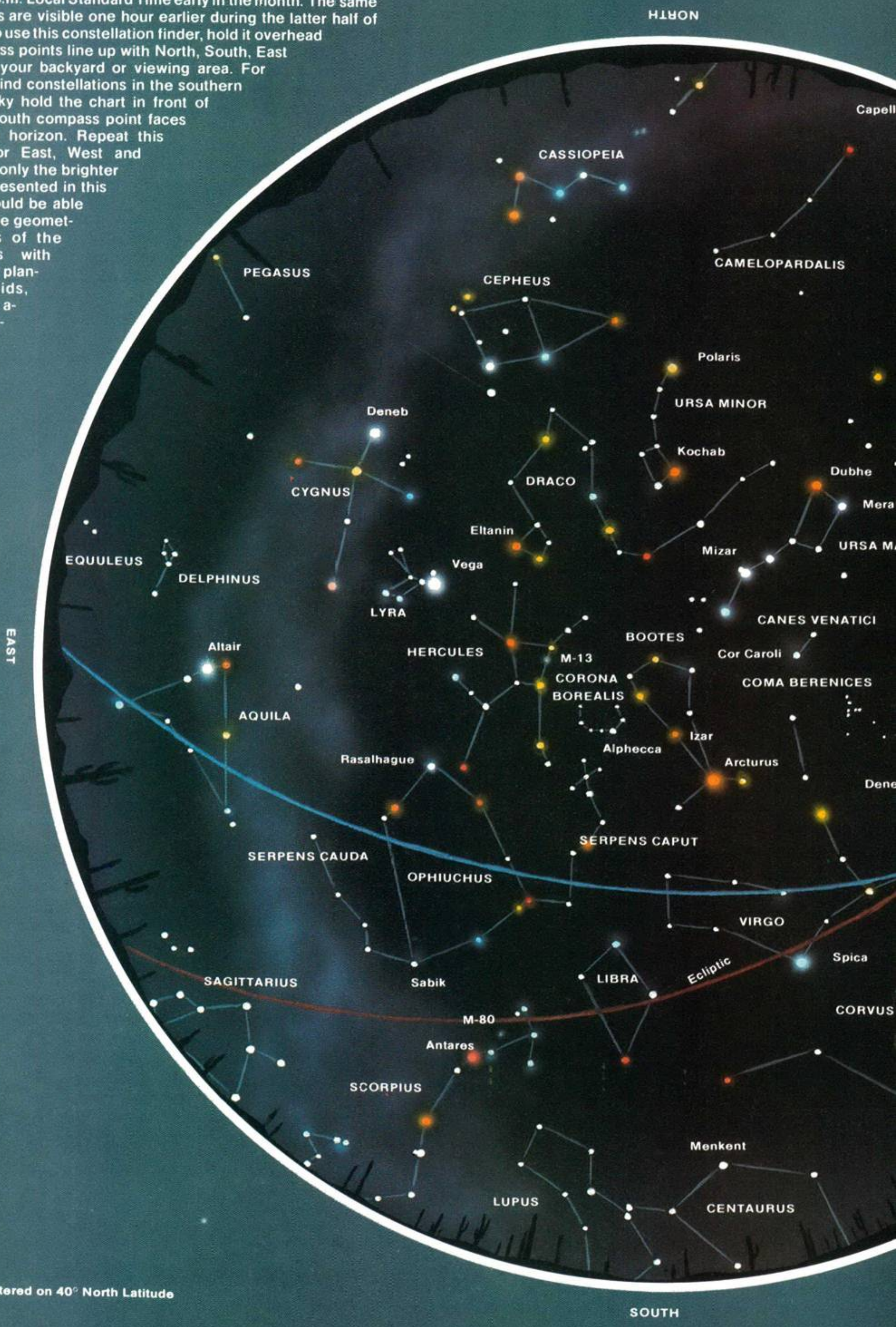
Among the four reptiles is Draco the dragon which, although never specifically identified as reptilian by the mythologists and storytellers who invented dragons, is invariably depicted as such in most artistic renderings. Our other reptiles are Serpens the snake, Chameleon, and Lacerta the lizard — the last two being modern inventions.

Our three invertebrates comprise a somewhat arbitrary class, as none of the three — Musca the fly, Cancer the crab, and Scorpius the scorpion — are zoologically related to one another. Both Cancer and Scorpius are found in the zodiac, leaving Musca as the only representative of the vast tribe of insects to be found in our sky.

Similarly arbitrary is our category of "landscapes" — it's just that we couldn't figure out where else to put these two constellations! They are Eridanus the river and Mensa, which represents Table Mountain, a real peak in South Africa from which French astronomer La Caille made his observations.

And so we return to our category of inanimate objects. Out of these 29 constellations, only eight date from ancient days. These are Ara the altar, Corona Australis the southern crown, Corona Borealis the northern crown, Crater the cup, Libra, Lyra the lyre, Sagitta the arrow, and Triangulum the triangle. One thing immediately noticeable about this group is that all but Ara, Libra and Lyra bear a distinct resemblance to the objects they are intended to signify — indicating that their inventors were being eminently practical when they formed these groups. You didn't need an elaborate myth or legend to explain how they got

This Star Dome rendering approximates the sky as it appears at about 10:30 p.m. Local Standard Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder on page **28**.


NORTH
EAST
SOUTH
Capell
CASSIOPEIA
CAMELOPARDALIS
PEGASUS
CEPHEUS
Polaris
URSA MINOR
Kochab
Dubhe
Mera
URSA MA
Deneb
DRACO
CYGNUS
Eltanin
Mizar
Vega
EQUULEUS
DELPHINUS
LYRA
CANES VENATICI
BOOTES
Altair
HERCULES
M-13
Cor Caroli
CORONA BOREALIS
COMA BERENICES
AQUILA
Izar
Alphecca
Rasalhague
Arcturus
Dene
SERPENS CAPUT
SERPENS CAUDA
OPHIUCHUS
VIRGO
Spica
Ecliptic
SAGITTARIUS
Sabik
LIBRA
CORVUS
M-80
Antares
SCORPIUS
Menkent
LUPUS
CENTAURUS

Map Centered on 40° North Latitude

AURIGA
GEMINI
Castor
Pollux
LYNX
M-44
CANCER
LEO MINOR
LEO
Regulus
Equator
SEXTANS
HYDRA
CRATER
WEST

Map by Adolf Schaller

in the sky; there they were already, just waiting to be identified! When we also consider that Lyra was once a bird (the vulture), and that Libra once formed part of Scorpius (the claws), it's difficult to escape the conclusion that ancient astronomers really weren't interested in placing inanimate things among the stars.

The other half of our Close-Up region this month is Lupus the wolf. Generally passed over in most of the classic observers' guides, Lupus is farther north than most people think: Almost all of it is visible from mid-northern latitudes, including most of the United States.

Closely associated with its neighbor Centaurus, Lupus is usually depicted in old atlases as impaled on a stake held in the centaur's hands. The wolf's stars are intermingled with the centaur's along their common boundary. In ancient Greece, this constellation was known simply as "the wild beast"; its appelation as a wolf came later — perhaps with the Romans (Romulus and Remus, the mythical founders of Rome, were suckled in infancy by a she-wolf).

Lupus has to rank as one of the skys most underrated constellations. In fact, it contains several second and third magnitude stars. Seen from Hawaii or locations farther south, it puts on a marvelous show!

Close-Up

Libra/Lupus Region

Nestled between the galaxy-crowded fields of Virgo and the bright Milky Way in Scorpius lies the zodiacal constellation Libra. Together with its southern neighbor Lupus, this somewhat dull-looking, and definitely neglected, region provides a kind of restful interlude from the dense extragalactic concentration to the west and the rich starclouds in the east.

Libra's main naked eye configuration is a quadrilateral or diamond shape formed by the stars Alpha (α), Beta (β), Gamma (γ) and Iota (ι), representing a celestial balance or scale midway up the southern meridian on clear warm June evenings. The adjoining constellation Lupus extends southward to below the horizon for most of our readers, its splash of second and third magnitude stars bordering the western edge of the Milky Way.

The Greeks combined Libra with Scorpius into one constellation, using the stars of the former to represent the claws of the latter. This accounts for the melodic and catchy names of Libra's two brightest units: Alpha is called Zubenelgenubi, and Beta is Zubeneschamali, meaning southern and northern claw, respectively.

Webb introduced Libra with the comment that "southerly declination combines with long days and late sunsets to give trouble in looking for the objects in this constellation, which are, however, well worth the pains." He bypassed Lupus entirely, as did most of the classical observers, because of its low altitude. (Most of these observers worked in Great Britain, which is farther north than most of the U.S., so much of Lupus was invisible.) Yet Lupus does have its share of visual showpieces, as our table of selected objects indicates. Although our descriptive cutoff for this group is about -40 degrees declination, there's plenty of buried treasure south of this arbitrary limit for those who dare explore at such forbidding celestial depths.

Alpha Librae

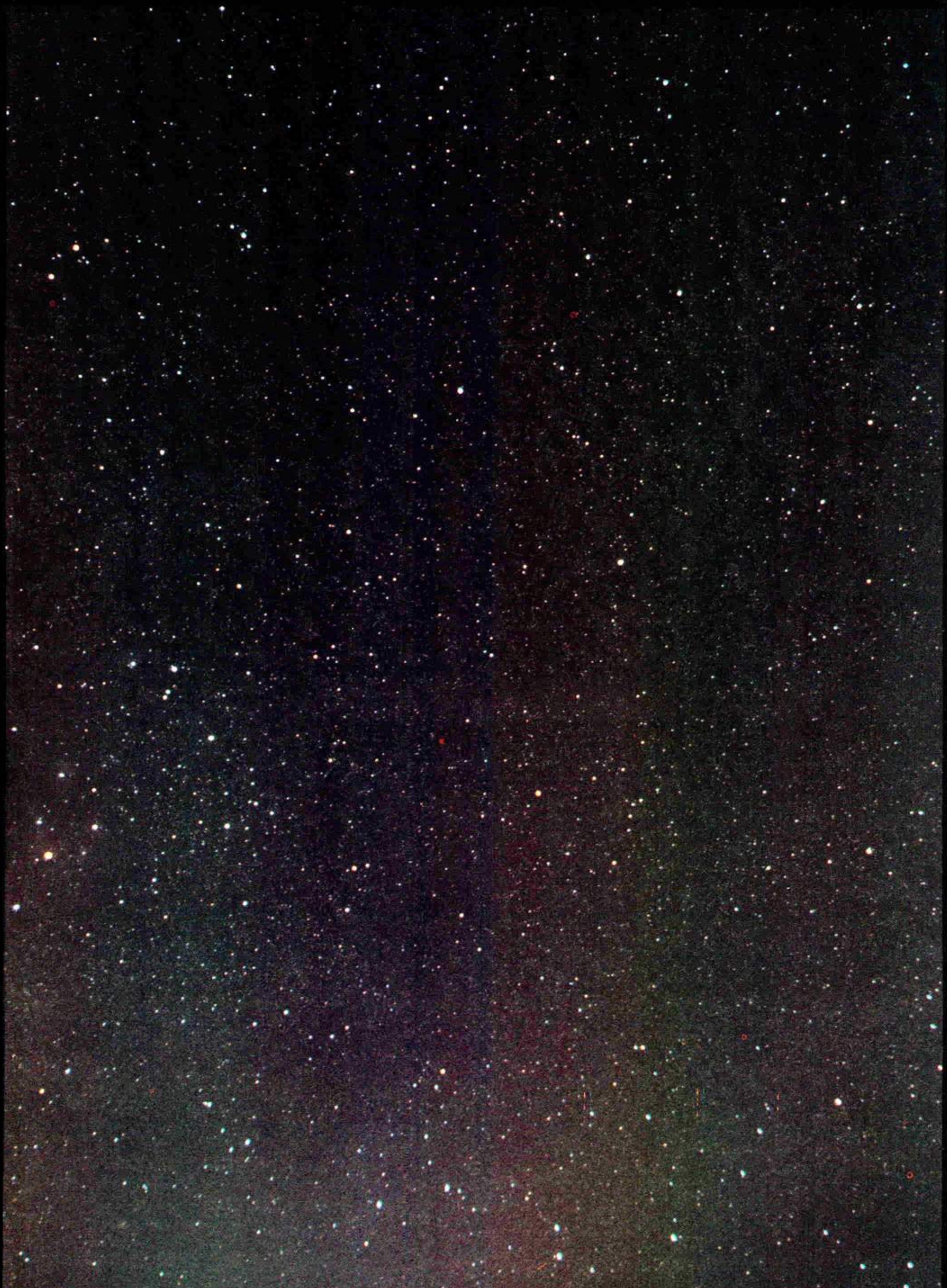
The western marker of the Libra diamond is the wide binocular duo Alpha Librae, situated nearly on the ecliptic. It consists of third and fifth magnitude suns (Alpha-2 and Alpha-1, respectively) a roomy 230 seconds (nearly four minutes) of arc apart. The slightest optical aid readily separates this pair, and it would be an obvious naked eye double if the stars were brighter and more nearly matched in luster than they are.

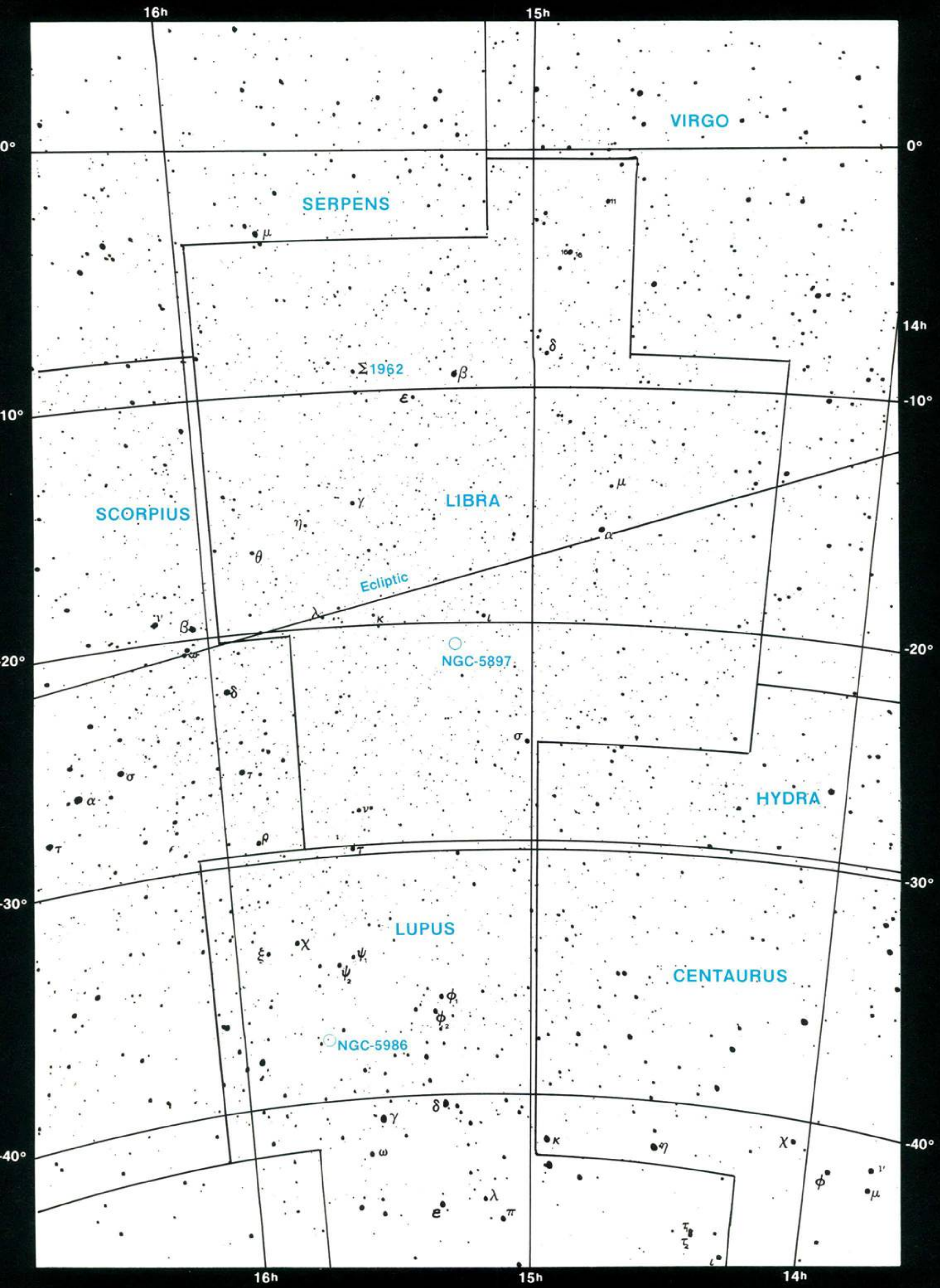
Alpha Librae has become more interesting over the past year because of its striking proximity to the planet Uranus. Binoculars or a richest field telescope (RFT) currently show both the double star and planet in the same field of view — the latter appearing as a greenish sixth magnitude object west of Alpha and very near 5 Librae. Our drawing, made from a four inch RFT at 15 power, shows the approximate position of Uranus in mid-June. Its motion over the coming months should be fascinating to watch; it will continue westward until about the third week in July, when it becomes stationary and then resumes eastward motion again, passing just north of Alpha late this fall. Here's a celestial "double feature" you won't want to miss!

Beta Librae

Slightly brighter than Alpha's combined light is the star Beta Librae, the northern member of the diamond. A single sun of spectral type B8 some 140 light-years distant, this object is noted for its unique greenish hue.

Webb called attention to Beta as follows: "Inserted for its beautiful pale green hue, very unusual among conspicuous stars: deep green, like

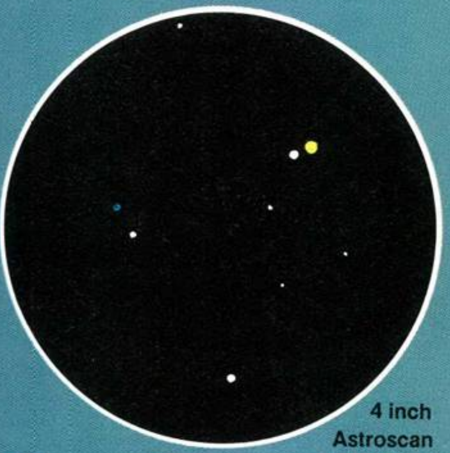



16h
15h
0°
0°
VIRGO
SERPENS
μ
11
16
14h
δ
Σ1962
β
ε
-10°
-10°
LIBRA
SCORPIUS
γ
μ
η
α
θ
Ecliptic
λ
κ
ι
ν
β
ω
NGC-5897
-20°
-20°
δ
σ
σ
τ
α
HYDRA
ν
τ
ρ
τ
-30°
-30°
LUPUS
ξ
χ
ψ1
ψ2
φ1
φ2
CENTAURUS
NGC-5986
δ
γ
κ
η
χ
-40°
-40°
ω
φ
ν
μ
λ
π
ε
τ1
τ2
ι
16h
15h
14h

Photograph by Brad Wallis and Robert Provin / Map by Richard Berry

Epoch 1950 coordinates

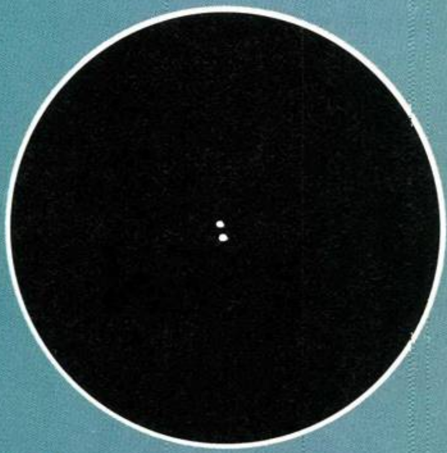
Alpha (α) Librae and Uranus



15X

4 inch Astroscan telescope

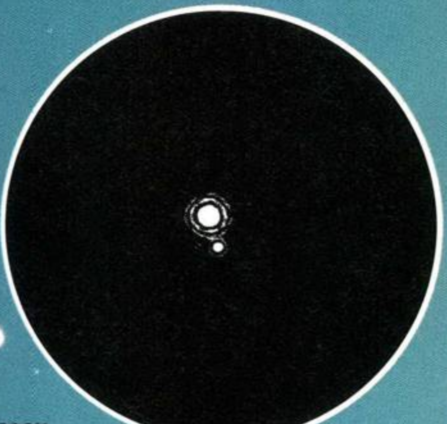
Struve 1962



30X

2 inch refractor

Eta (η) Lupi



200X

5 inch Schmidt-Cassegrain

Top left: Alpha Librae is a bright wide double, easily resolved in the smallest telescopes or binoculars. Observers of this double will be triply rewarded this month because the planet Uranus will lie in the same low power field as the double. Bottom left: Eta Lupi offers a fine faint star near a primary, dazzlingly bright by comparison. With small telescopes, the pair is more of a challenge than its 15 second separation would suggest, because of the large magnitude difference and the southerly declination of this pair. Right: Struve 1962 is an evenly matched pair close enough to really look double, but separated far enough to be easy even in small telescopes. Drawings by James Mullaney.

Selected Objects — Libra/Lupus Region

Object	Type	Mag.	Size	R.A. (1950)	Dec.
LIBRA					
μ (Mu)	★2	5.8,6.7	1.7"	14^h47^m	-13°57'
* α (Alpha)	★2	2.9,5.3	230"	14^h48^m	-15°50'
* δ (Delta)	V:2.3d	4.8-5.9	—	14^h58^m	-08°19'
* ι (Iota)	★3	4.7,10,10	59",2"	15^h09^m	-19°36'
* β (Beta)	★Gr	2.7	—	15^h14^m	-09°12'
* NGC-5897	GC	10	7'	15^h14^m	-20°50'
* Σ 1962	★2	6.5,6.6	12"	15^h36^m	-08°38'
LUPUS					
π (Pi)	★2	4.7,4.8	1.7"	15^h02^m	-46°51'
NGC-5822	OC	6.4	40'	15^h02^m	-54°09'
κ (Kappa)	★2	4.1,6.0	27"	15^h08^m	-48°33'
μ (Mu)	★3	5.0,5.2,7.2	1.4",24"	15^h15^m	-47°42'
ϵ (Epsilon)	★2	3.9,6.0	1"	15^h19^m	-44°31'
ν (Gamma)	★2	3.6,3.7	1"	15^h32^m	-41°00'
* NGC-5986	GC	8.7	4'	15^h43^m	-37°37'
* ζ (Xi)	★2	5.4,5.7	11"	15^h54^m	-33°49'
* η (Eta)	★2	3.6,7.7	15"	15^h57^m	-38°15'

*Detailed in Close-Up

★2=Double Star
★3=Triple Star
★Gr=Green Star
V:#d=Variable Star, period

OC=Open Cluster
GC=Globular Cluster
Mag.=Magnitude
Sep.=Separation

deep blue, is unknown to the naked eye." Barns called this solitary gem a "pale emerald unit, resembling Uranus", while Muirden noted it "...has a somewhat greenish tinge, which is not, however, obvious to the casual glance."

The late Harvard astronomer Donald Menzel considered B type stars to be bluish in color and A suns (the adjoining spectral class) as greenish. At B8, Beta Librae lies perhaps somewhere between these two shades of white. What heavenly frequency do you find lurking here?

Delta (δ) Librae

Our third offering is an eclipsing binary system, similar to famed Algol in Perseus, that you can easily see "winking" at you with the unaided eye and binoculars from across the depths of interstellar space. This is Delta Librae, located four degrees west and one degree north of Beta.

Delta is brighter than fifth magnitude for most of its 2.3 day period, and is obvious without optical aid. During its 13 hour eclipse, however, it fades by more than a magnitude to near the naked eye limit for most observers, and may require binoculars to be seen, depending on your sky conditions. Its variability was discovered by Schmidt in 1859, who gave the period then as 2 days 7 hours 51 minutes, with the comment that it was increasing. [Period changes in eclipsing binaries are well established today, and they provide valuable information on the dynamics of such systems. Timings of the minima of such variables is a field for useful work, and such activities are coordinated by the A.A.V.S.O. (American Association of Variable Star Observers) in this country.]

Comparison stars that can be used for casual monitoring of Delta's light level include Epsilon (ϵ) Librae (magnitude 5.1, two degrees southeast of Beta) when Delta is outside of eclipse, and the double star Struve 1962 (combined magnitude 6.1; see below) near Delta's mideclipse. It's fun trying to catch this sun at minimum light; you can easily calculate times of future minima by adding multiples of the period.

Barns called Delta Librae "a very notable object", and so it is. Here you can witness the mutual revolution of two distant suns — the eclipse of one star by another — with no equipment other than the unaided human eye!

Iota Librae

For a change of celestial fare — and a bit of cosmic challenge, as well — take a look at our next subject. This is the triple star system Iota Librae, marking the southern tip of the diamond some 10 degrees due south of Beta. This object is also known as 24 Librae; there's another star of sixth magnitude (25 Librae) in the same field to the northeast, adding to the overall scene.

Some observers of the past regarded Iota as simply a wide unequal double, of magnitudes 4.7 and 9.7 with a separation of 59 seconds and a position angle near 110 degrees. Olcott, for example, noted it as a "yellow-purple" double and stated it was difficult in his three inch refractor. Barns also logged it as a double star, calling its components "wide guide-stars to cluster NGC-5897" (see below).

Actually Burnham long ago divided the fainter component with his six inch refractor into two 10th magnitude stars 1.8 seconds apart. At that time the position angle of this close pair was 25 degrees, but it has been slowly decreasing. These suns form a physical binary which is drifting through space with the 4.7 magnitude star, which itself is a close spectroscopic binary. Neighboring 25 Librae also has an unseen spectroscopic companion, and the star lies at nearly the same distance (250 light-years) and has the same proper motion as Iota. Thus we may be viewing a far-flung multiple star system, having at least six members in its clan.

Brown mistakenly identified Iota as being formed by both 24 and 25 Librae. His description actually refers to Iota and its faint attendant: "The primary star is magnitude 4.7 pale yellow with a magnitude 9.7 red-purple companion." He pointed out that the latter object is a close 10th magnitude pair. Webb and Muirden both listed Iota as an irregular variable star having a range from 4.3 to 5.0, but it is missing from most variable star lists and catalogs. Can you confirm this alleged variation with your own observations of this object?

Struve 1962

Typical of the vast multitude of double and multiple stars scattered about the sky from the catalogs of the Struves is the neat stellar duo Struve 1962. Look for it in your finder suspended in relative isolation some 5-1/2 degrees east and 1/2 degree north of Beta Librae. Even a two inch scope at just 30 power divides this exquisite pair, as shown in our drawing.

Struve 1962 consists of a nearly perfectly matched set of white gems at magnitudes 6.5 and 6.6, some 12 seconds apart in position angle 190 degrees (nearly north-south on the sky). Webb called the components of this long period binary both white in color and regarded it "a striking object".

Why all this fuss over a relatively faint and obscure double star? It probably has something to do with seeing two so exactly matched suns at perhaps optimum separation for smaller instruments. You should really take a look and see for yourself!

NGC-5897

Our final stop in Libra before heading south into Lupus is an inconspcuous globular cluster of stars known as NGC-5897. Sweep for it with a low power eyepiece on the telescope itself, at a point in the sky some two degrees southeast of Iota.

Also designated H-VI^{19} (the 19th discovery in Sir William Herschel's class VI: very compressed and rich clusters of stars), this distant stellar beehive is about seven minutes in size and no brighter than 10th magnitude visually. As globulars go, it is classified as poor in its concentration of stars. A four inch telescope at 45 power will readily pick it up, but at least an eight inch aperture at 100 power or more is needed to resolve its outer edges on a typical night.

Webb described NGC-5897 as a "globular cluster of small stars", and Muirden logged it as "large and dim". Barns listed it as H-V^{19} in error, calling it "a universe of remote suns" in his 10 inch reflector. The NGC itself records this object as a "globular cluster, pretty faint, large, very irregularly round, very gradually brighter in the middle, well resolved, clearly consisting of stars". This account is that of its discoverer, Herschel.

This cluster is all but lost and forgotten by astronomy enthusiasts in the dazzling array of bright summer globulars, and few modern observers have ever seen it. Why not pay this lonely orb a visit on the next clear moonless night?

Xi (ξ) and Eta (η) Lupi

Descending into Lupus now, we present two samples of its rich treasure trove of bright double and multiple suns, which seem to increase in number the farther south we go, merging at last with the glittering clusters of the summer Milky Way.

Farther north of the two at -34 degrees declination is Xi Lupi, a pair closely resembling Struve 1962 in Libra, but brighter. It is made up of 5.4 and 5.7 magnitude suns about 11 seconds distant near position angle 50 degrees. You will find it about a degree southeast of fourth magnitude Chi (χ) Lupi. Although Muirden noted this object as "a fine pair", it was bypassed by most of the classical observers because of its low altitude. A three inch refractor at 45 power beautifully divides Xi when the air above the southern horizon is steady, as it often is during the summer months.

The second duo is Eta Lupi, a fourth magnitude star near the Scorpius border, easily picked out with the unaided eye. Here we encounter 3.6 and 7.7 magnitude suns 15 seconds apart near position angle 20 degrees, offering a fine magnitude contrast for small telescopes. Eta is a slow moving binary system, and at least one observer of note suspected it of being a variable star as well, but did not mention which component was in question. At declination -38 degrees, this object has received little attention from observers, both past and present. Yet it is well worth locating, as our drawing with a five inch Schmidt-Cassegrain catadioptric at 200 power suggests.

NGC-5986

We conclude this month's explorations with a final stop at a far southern globular cluster at -37-1/2 degrees declination. This is NGC-5986, an 8.7 magnitude bundle of stars four minutes in diameter and of medium concentration. (Remember that atmospheric absorption will reduce the brightness of such low lying objects, making them appear fainter than the catalog magnitudes suggest.) Sweep for it three degrees northwest of Eta Lupi, situated between two faint naked eye stars. These lie about 1/3 of the way from Eta to Phi-1 (ϕ) Lupi, and are easily picked up in a finder.

Discovered by Sir John Herschel during his survey of the southern heavens from the Cape of Good Hope, his description of this object as recorded in the NGC reads: "Remarkable. Globular cluster, very bright, large, round, very gradually brighter in the middle, stars 13...15th magnitude." Muirden's impression is one of the very few available from modern observers: "A bright globular cluster, but unresolved in a small telescope; visible in the finder."

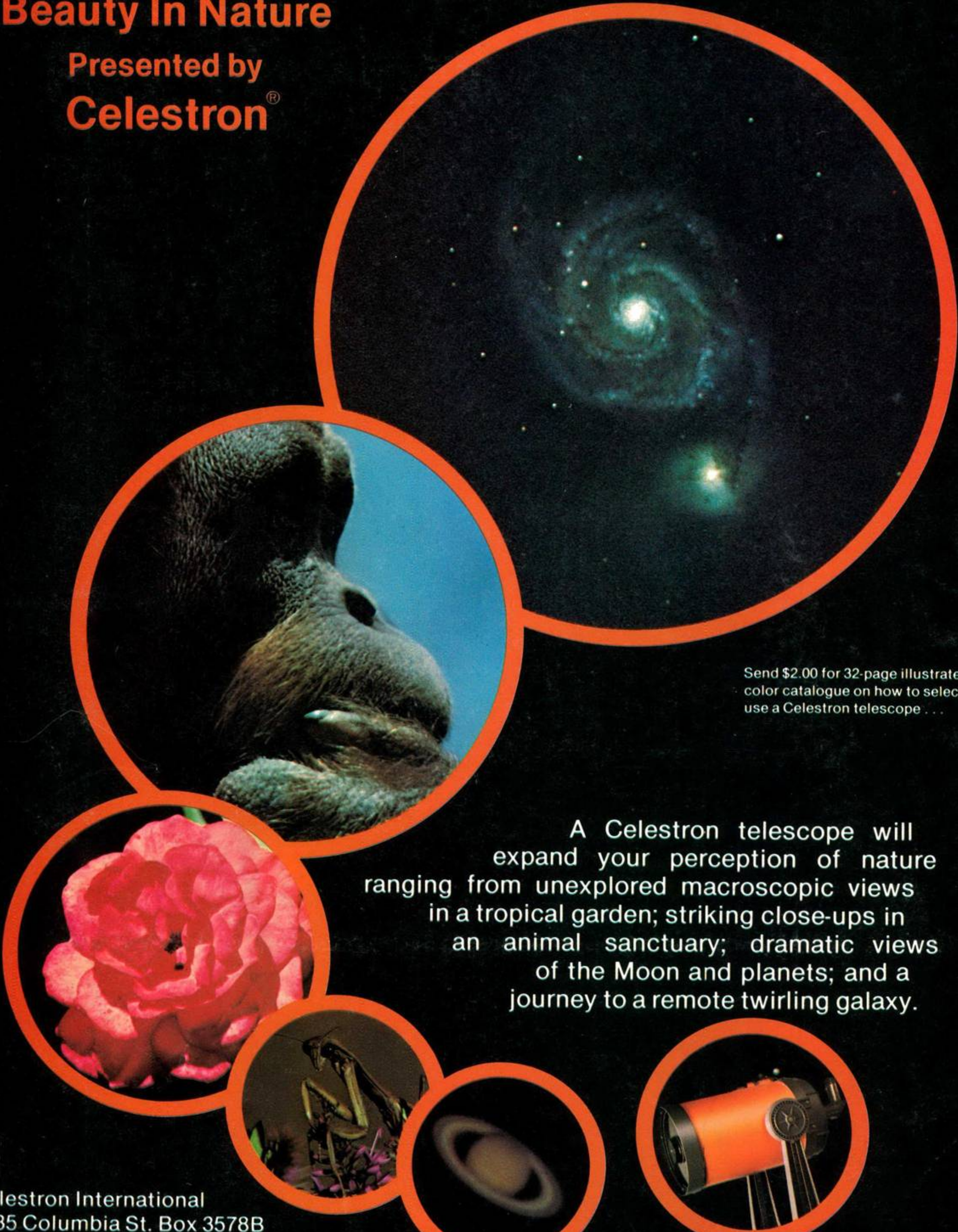
To fully appreciate the wonders of low declination precincts like Lupus, it's necessary to go south to at least the tropics. There you'll find that Lupus is simply packed with beautiful open and globular clusters. Northern observers who have made the trip south frequently remark that you haven't really seen the stars until you view them from near the equator or the southern hemisphere, bringing to mind the inspired words of Emerson:

"If the stars should appear one night in a thousand years, how men would believe and adore, and preserve for many generations the remembrance of the City of God which had been shown! But every night come out these envoys of beauty, and light the universe with their admonishing smile."

Beauty In Nature

Presented by

Celestron®



Send $2.00 for 32-page illustrate
color catalogue on how to selec
use a Celestron telescope . . .

A Celestron telescope will expand your perception of nature ranging from unexplored macroscopic views in a tropical garden; striking close-ups in an animal sanctuary; dramatic views of the Moon and planets; and a journey to a remote twirling galaxy.

Celestron International
2835 Columbia St. Box 3578B
Torrance, CA 90503
(213) 328-9560

Celestron photos